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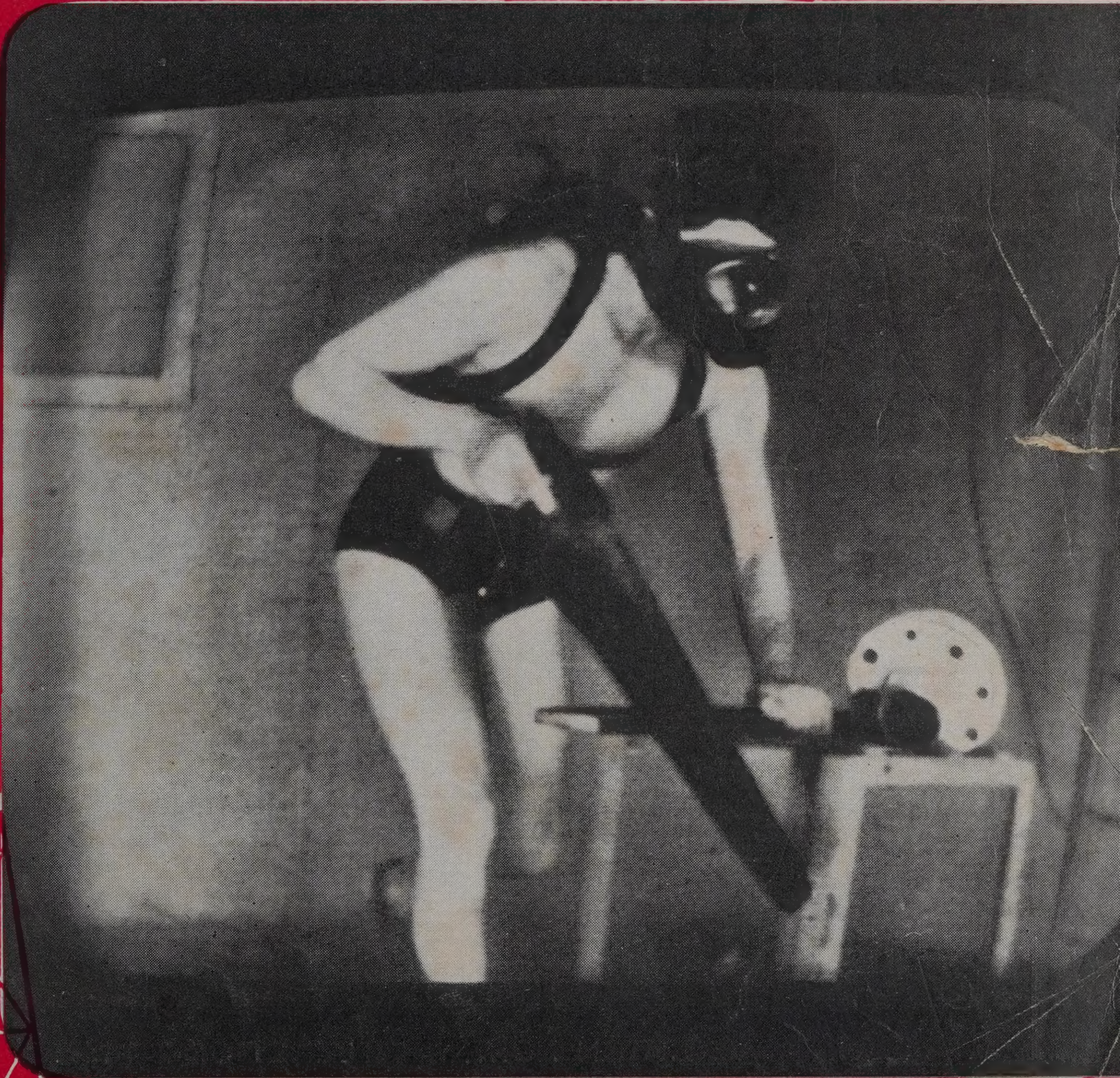
RADIO and ELECTRONICS

ELECTRICITY —— COMMUNICATIONS —— SERVICE —— SOUND



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OUR COVER

This month's cover picture was taken from the screen of the receiving cathode ray tube of the Marconi-Siebe-Gorman underwater TV equipment, showing a man working under water in the test tank. This gives some idea of the extremely good vision provided by the TV gear. It is stated that the views obtained are often better than what is seen by an actual diver and, of course, it is not necessary for a diver to relay long descriptions of the conditions below to those on the surface.

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Advertising Manager:
CHAS. H. ROSER

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CORRESPONDENCE:

All correspondence and contributions should be addressed to:

The Editor,
"Radio and Electronics,"
P.O. Box 8022,
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OFFICES AND LABORATORY

Radio and Electronics (N.Z.), Ltd.,
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An Editorial Blunder

It is not often that the Editor of a periodical such as this is pleased to admit to an error in fact, but such is the case in the present instance. In our June, 1952, issue, "the Walrus" in his article entitled "High Frequency Communication," committed an error for which the Editor must claim responsibility. In writing about vacuum-enclosed quartz crystals, our contributor stated: ". . . This type of crystal, however, can only be successfully made overseas. . . "

It appears that this statement, though true until quite recently, is no longer so. The Director of the Dominion Physical Laboratory, Dr. A. G. Bogle, has written to us pointing out the error, and giving the true facts of the case. We have pleasure in reproducing Dr. Bogle's remarks here. He writes:

"We should like to point out that during the last year, this laboratory has been developing for the Post and Telegraph Department, the equipment and technique for the manufacture of this type of crystal. The P. & T. Department intend to use the equipment for the manufacture of their own evacuated crystals. The prototype has operated successfully, and production gear is shortly to be assembled."

It is good to hear of technological advances made in our own country, and especially in fields such as the production of frequency-determining crystals. While it is true that world distances have shrunk immeasurably owing to high-speed air travel, the fact that such key components can be produced here, even in small quantities, could be of very great importance under certain circumstances. The Dominion Physical Laboratory is to be congratulated on the successful development of this equipment, and we hope that next time work of a similar general nature is carried out here, Dr. Bogle will let us have the news before we put our editorial foot it in, as it were! By "work of a similar general nature," we, of course, do not mean further work on crystals, but any extension to our technological facilities that may have application to the electronic field. The general public does not have very much idea of the advanced nature of the work carried out by our own back-room boys, and institutions like the D.S.I.R., generally, and the Dominion Physical Laboratory in particular can certainly not be said to suffer from an excess of publicity. Much of their work, we believe, is of a secret or confidential nature, but since the war, when so many scientific developments were defence secrets, there seems to have been a general tendency in all countries, to classify as secret, work that has no possible security aspect. Another point which is probably responsible for the lack of publicity given to this country's scientific work is the relative scarcity of publications of a technical nature. The daily press is not interested in scientific news unless it bears on some topic of wide public interest, such as television, or unless it has some sensational press value. On the other hand, purely scientific journals are interested only in complete papers on original work. Added to this, it would seem that much of the work done by D.S.I.R. is not published, in the generally accepted sense, at all. No doubt it is written up for departmental consumption only, but there must be much of it which could advantageously see the light of day in a much wider manner than it does. The New Zealand Broadcasting Service, too, has technical facilities and a technical staff that can bear comparison with those of any similar body in the world, and much of the work that goes on behind virtually closed doors would be of considerable interest to those engaged in the electronic profession both here and elsewhere. It seems a pity, therefore, that this work, too, is not published. "Radio and Electronics" has been likened to New Zealand's "Wireless World," and while this may be an unduly flattering description, it does indicate that articles written by New Zealand electronic workers, describing their own particular achievements would not be out of place in this journal, which circulates not only in this country, but in Britain, America, Australia, and other countries, as well. Such articles would do much to increase the prestige of our electronics industry. New Zealand problems in broadcasting, radio communications, and allied spheres are not exactly those that have been overcome in other countries. We have our own contributions to make to the general sum of knowledge in these matters, and it would be well if they could be made, not only for the enlightenment of our own technical men, but for the world at large. Several examples come to mind, which there is not space here to elaborate, but the statement of the principle alone should be sufficient. We hope that it may fall on receptive ears.

The "R. and E." 807 Standard Amplifier

The circuit described in this article is intended to fill the need for a relatively inexpensive amplifier giving a nominal 10 watts output, and capable of playing 78 or long-playing records without additional compensating stages. The built-in compensation stage makes the amplifier suitable for use with either a radio tuner, or with either type of record.

INTRODUCTION

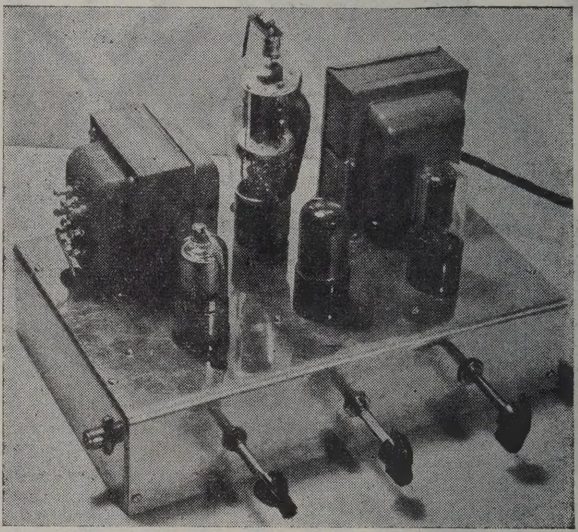
The current long-playing boom has apparently caused a remarkable recrudescence of interest in gramophone amplifiers and all that goes with them, such as dual-speaker systems, response compensation circuits, dividing networks, and so on. This is not really surprising, because gramophone recordings today allow a standard of reproduction that a few years ago could only have been heard in broadcasting studios and such places, where expense is a secondary consideration. Along with the improvements in records themselves have come vastly improved pick-ups and good loudspeakers that people can afford. In short, we hardly realize how lucky we are in being able to produce such excellent reproduction at such low cost. Indeed, it seems that quality reproduction has become about the only thing which is better than pre-war, while costing less. No doubt there are some who will argue that this is not so, because it is just as possible today to pay tremendous prices for audio equipment as it used to be. Be that as it may, we are quite convinced that the man in the street, without expending untold sums, can now extract much more pleasure from gramophone records than it was possible to do only a few years ago.

Recent experience seems to have shown, also, that amplifier distortion is not usually the factor which determines whether our equipment sounds really well. By this, we do not mean to say that distortion in amplifiers is no longer to be avoided. Far from it. What we do mean is that most of the horrible-sounding noises we have been unwillingly accustomed to hearing have been due to inferior pick-ups and speakers rather than to vast quantities of distortion in our amplifiers. Of course, some of the improvement must be due to the excellent characteristics of the amplifiers we now use, and it is quite probable that our standards have been so modified by the publication of circuits such as the "Williamson," and others of similar quality, that we will no longer tolerate amplifiers which would have been classed as good in less enlightened days.

All of which brings us, by a devious route, to the subject of the present article. We have said before, with more than a little justification, that the modern trend towards push-pull amplifiers for all but the cheapest and least complicated gear has tended to obscure the fact that excellent single-ended amplifiers can readily be built that will compete on even terms with the less pretentious of the push-pull amplifiers. In fact, unless the said push-pull amplifiers are properly designed and built, a good single-ended amplifier can and will put them to shame.

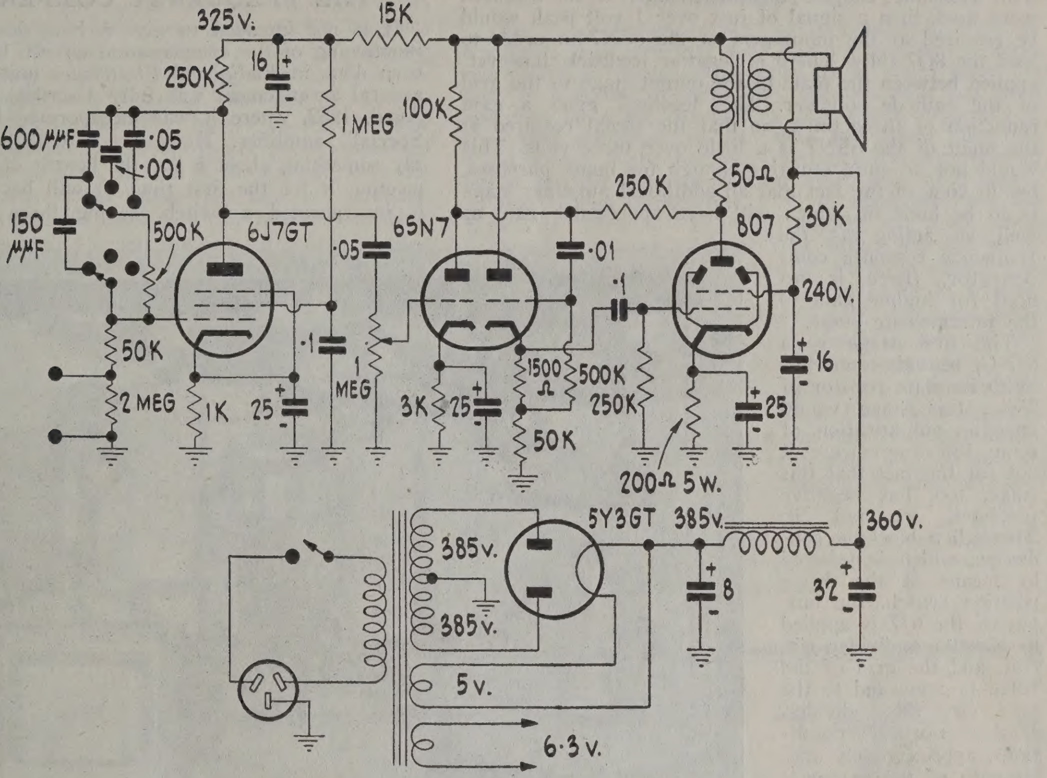
PURPOSE OF THIS AMPLIFIER

From the above remarks, readers will no doubt have gathered that one of the purposes behind this amplifier is to vindicate the single-ended amplifier, as a type. It has not, however, been built to prove a theory, but rather as an exceedingly useful piece of equipment. For a circuit using only four valves, inclusive of rectifier, this one has much to offer. It uses a fairly high degree of negative feedback in such a way that difficulties from oscillation are virtually impossible. Thus, the low distortion of the feedback amplifier is achieved with the least amount of difficulty to the builder. Secondly, it follows the very desirable practice, first illustrated in these pages by the "78-L/P Special," of building into the main amplifier the response compensation that is so essential if the best results are to be had from both ordinary and long-playing records. Previously, it has been the habit of designers to present an amplifier with a flat frequency response, and an average sensitivity, suitable for a radio tuner and for high-level pick-ups. Then, if modern high-quality magnetic pick-ups were to be used with it, an additional compensation stage had to be added as an outrigger. The latter has never been a very satisfactory process, for a variety of reasons, so that the policy of *Radio and Electronics* of giving amplifier circuits with the necessary compensation built as an integral part of them will, it is felt, receive wide approval from its many readers who are interested in audio work.



View of the completed amplifier. The input socket can be seen on the left-hand side of the chassis. The left-hand control is the switch for the compensation, the centre one is the volume control, and the remaining one a power on/off switch.

By means of a dodge that is not so well known as it might be, this amplifier, and others like it, may be used for either crystal or magnetic pick-ups without alteration of the amplifier circuit in any way. This is an advantage that the writer has seldom seen claimed, but it is none the less a real one, and can save a great deal of heart-burning on the part of those who wish to change their pick-up type without rebuilding their amplifier. It is true, of course, that some of the best magnetic pick-ups



have so low an output voltage that an additional stage of amplification is still necessary, but when an amplifier of the kind under discussion is used, all this means that additional *gain* must be provided. This is quite easily obtained; a high-gain stage will not normally be required, since the extra gain necessitated by the compensation has already been provided, *in the amplifier proper*. The old method of providing both compensation and additional amplification made it necessary for the outrigger stage or stages to give a gain of about 500 times, all told, if the output of a 15-millivolt pick-up was to be brought up to a level of one volt and at the same time compensated for the frequency characteristic of the record.

A third feature of this amplifier is that its power supply requirement is very slight compared with that of a 10-watt amplifier utilizing a push-pull output stage. In the prototype model, illustrated in the photographs, a 385-volt 80 ma. transformer was used, together with a 5Y3 rectifier and a condenser-input filter, and this compares very favourably with some 10-watt amplifiers, which sometimes need as much as 400 volts a side, at 150 ma.

THE CIRCUIT IN DETAIL

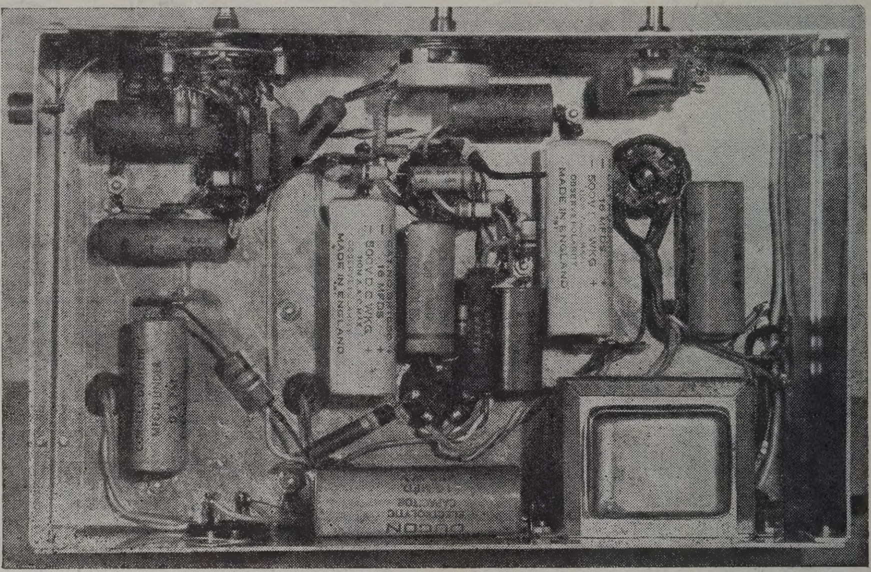
For the output stage, the ubiquitous 807 was the obvious choice. In the first place, many builders have already provided themselves with these tubes at the one-time surplus prices, and would like something for them to do! Secondly, there are very few other valves which will give a nominal output of 10 watts all by themselves. The choice of a beam-tetrode, as distinct from the alternative of a triode, was also dictated by economics, both because it requires less driving voltage and because of its high efficiency, which again means a lighter power supply than even the single triode would need.

The circuit of the output stage is not quite the same as we are accustomed to for a single tetrode, because the tube is being worked with lower voltage on the screen than on the plate. This has been done because of the maker's recommendation that when the higher plate voltages are used the screen voltage should be kept down to 250 or 275 volts. There is a set of conditions for a single 807 in which 11.3 watts output is obtained with 375 volts on the plate and 250 on the screen, and this would be a very desirable form of operation for our present purpose. Unfortunately, however, the transformer and rectifier that would have to be used to give these voltages would not be a stock item, so that in our amplifier we have compromised with a standard 80 ma. transformer, 385 volts a side. This gives an output at the second filter condenser of 360 volts for the plate of the 807, and the 250 volts for the screen are provided by the use of a dropping resistor. Because of the resistor, it is necessary to bypass the screen, and a 16 μfd. condenser has accordingly been used. The power output with these voltages is not as high as the 11.3 watts quoted in the manufacturer's data, but it is not far short of the 10-watt mark. Indeed, it is greater than can be got from a pair of 6V6s in push-pull, so that builders will find nothing to complain about so far as output capability is concerned.

The next valve is a 6SN7, used in a rather unconventional way. The section feeding the grid of the 807 is connected as a cathode follower, which in turn is fed from the remaining 6SN7 section, which is a low-

gain resistance-coupled amplifier stage. If no feedback were used, then a signal of just over 1 volt peak would be required at the input grid of the 6SN7 in order to load the 807 fully. There is negative feedback, however, applied between the plate of the output stage to the grid of the cathode follower. This feedback gives a gain reduction of three times, so that the signal required at the input of the 6SN7 is a little over three volts. This would not be quite sensitive enough for many purposes, but in view of the fact that an additional amplifier stage is to be built in, which will have appreciable gain as well as acting as the frequency response compensator, there is no need for higher gain in the intermediate stage.

The first stage is a 6J7-G, pentode-connected. With its plate resistor of 250k., this stage would have an amplification of some 185 times were it not for the fact that this stage, too, has negative feedback round it. Through a blocking condenser, which is selected by means of the three-position switch, the output of the 6J7 is applied to a voltage divider circuit, and the grid of the valve is connected to the tap on this divider. Under normal conditions, approximately one-eleventh of the output is fed back, so that the stage gain is reduced from 185 to the much lower figure of 10.4 times. This being the case, the peak input voltage to the input stage, for full output from the amplifier is 0.38 volts, and this will be recognized as the same sort of figure as is usual in ordinary audio amplifiers not provided with a frequency compensation stage.



Another unusual feature of the circuit is that, contrary to ordinary practice, the volume control is not to be found in the grid circuit of the first stage, but in that of the second stage. There is normally a very good reason why this arrangement is not normally used. It is that if the control is right at the input of the amplifier, it is impossible for any of the valves to overload and produce distortion before the output stage itself has been overloaded. Provided, that is, that the amplifier has been properly designed in the first place.

In the present instance, the usual practice would have been followed had the circuit allowed it, but the compensation stage is not really suitable for having a volume control in its grid circuit, since any arrangement that can be thought of will affect not only the amount of signal fed into the amplifier, but also the feedback, and hence the gain of the first stage. In practice, this means simply that it is necessary to ensure that too great a signal is not fed to the input terminals. If it is, the symptoms will be unmistakable, because it will be found that bad distortion is produced even when the output of the amplifier is quite small. If this behaviour is found, all that has to be done is to reduce the input to the amplifier until the distortion disappears. We will have more to say about this later on in the article.

THE FREQUENCY COMPENSATION

It is not intended to give a long description of the functioning of the compensation circuit, because this has been done in *Radio and Electronics* quite recently. The general arrangement was fully described in the issue of April, 1952, where it was incorporated in the "78-L/P Special" amplifier. However, it will be necessary to say something about it for the benefit of those who are meeting it for the first time. It will be seen that there is incorporated a switch, having three positions. The right-hand position puts a 0.05 μfd. condenser in series with the 500k. and 50k. voltage divider. This size of condenser allows the feedback to be substantially the same ,all over the audio range, so that in this position all that the feedback does is to reduce the stage gain equally at all frequencies. As a result, the whole amplifier has a flat response curve when the switch is in the right-hand position.

In the middle position, the circuit is unchanged, except that the blocking condenser is now reduced to 0.001 μfd. As a result, the voltage fed back at low frequencies is much less than that fed back at middle and high frequencies. Consequently, the stage gain is high at low frequencies and low at middle and high frequencies. This is the same thing as saying that we have introduced bass boost. The proportions of the feedback circuit determine how great the boost will be, while the size of the blocking condenser decides for us the frequency at which the boost becomes effective. This position of the switch is intended for compensation for ordinary 78 r.p.m. recordings, and so the 0.001 μfd. condenser has been chosen so as to make the boost start working at about 300 cycles per second, which is the right spot for these records. Below this frequency, the gain steadily increases, so that the progressive falling-off of the bass that is incorporated in 78 r.p.m. recordings is properly compensated for. At frequencies above 300 c/sec., the response is flat.

In the left-hand position, the blocking condenser is altered to 600 $\mu\mu$fd., and at the same time an extra condenser of 150 $\mu\mu$fd., is connected across the 500k. resistor in the feedback chain. The blocking condenser in

this position is of such a size that the bass boost starts at a higher frequency—500 c/sec. to be precise—and this is suitable for the bass compensation for long-playing records. The purpose of the 150 $\mu\mu$fd. shunt condenser is to give the amplifier a drooping characteristic at frequencies above 2000 c/sec. This has to be done because these frequencies on L/P records are pre-emphasized in the recording process, so that if the top-cut were not used these records would sound very thin and scratchy, and not at all nice. So much now for how the compensation switch works. The flat position, of course, is used when no frequency compensation is needed, as when the amplifier is being fed from a radio tuner.

There is one point about the input circuit that has not yet been explained. It is the presence of the 2 meg. resistor, connected to earth from the bottom end of the 50k. resistor. Actually, this resistor serves no other purpose than to ensure that the grid circuit of the 6J7 is not opened when nothing is connected to the input terminals. When a magnetic pick-up is connected in, its coil resistance is only a few hundreds, or at most thousands, of ohms, so that it effectively short-circuits the 2 meg. resistor. For crystal pick-ups, an additional resistor, of fairly low value, is needed across the pick-up leads, and this again short-circuits the resistor.

POWER SUPPLY

This is so straightforward as to require little or no comment. It is true that a 5Y3 is not supposed to have more than 350 volts A.C. applied to its plates when the filer is a condenser-input one, but this tube has been specified, since the overload is very slight, especially if the input condenser is not made any larger than the 8 μfd. shown on the diagram. The stock transformer used has a rectifier filament winding rated only at 2 amps., so that if this transformer is to be used, we have the choice of using a 5Y3 with slightly too much plate voltage, or of using a 5Z3 or 5U4, with a filament winding rated at only 2 amps. Actually, we do not think that any of these things will be likely to result in trouble. It is doubtful whether the extra 35 volts will appreciably shorten the life of the 5Y3, and equally so whether the transformer would be appreciably overloaded if a 5U4 or 5Z3 were used instead. The only word of warning we would stress is that if the 5Y3 is used, as suggested, on no account should the input condenser be made larger than 8μfd. The smoothing is very good, and the hum in the output negligible, without changing the filter arrangements in any way.

In our next issue we will present some notes on the use of various types of gramophone pick-up, and of radio tuners with the amplifier.

The Poor Man's Signal Generator

The idea of using a multivibrator for aligning radio receivers is by no means new, but is not nearly as well known as it should be. The simple "signal generator" described in this article is portable, independent of A.C. mains, and will enable all-wave receivers to be aligned without recourse to the gang-rocking technique that must be used with an ordinary R.F. oscillator.

INTRODUCTION

One of the biggest problems of the amateur radio constructor is that of aligning a receiver, once it has been constructed. It is consequently quite common for servicemen to be confronted with home-built sets which require alignment because the builder has not the equipment, or does not consider himself competent to line it up himself. Many constructors feel that alignment is a job for someone with a proper signal generator and output meter, and so it is, strictly speaking, but since most builders use commercially made I.F. transformers and coils, or coil units, there is really no necessity for the alignment to be done with these instruments. A perfectly good job of it can be done by an experienced person without any instruments at all, but it is not an easy process for someone who may not have aligned a set before! The average amateur constructor feels, justifiably enough, that the money represented by the purchase of even a simple commercial signal generator would largely be wasted, as would the effort expended in building something for himself.

This little instrument, however, puts a very different complexion on matters. The outlay is very slight by comparison with ordinary signal generators, and yet it enables I.F. amplifiers to be aligned, not to mention the signal circuits of broadcast and all-wave sets. To make the picture brighter still, it should be mentioned that with a multivibrator, as used here, adjusting the padder condenser on the broadcast band (or any other band on which a variable padder is used) is just as easy as peaking up the trimmers at the high-frequency end of the dial. Thus, the greatest difficulty that confronts the experienced operator—that of properly tracking the set with trimmers and padder, is removed as it were, at one stroke.

PRINCIPLES OF THE DEVICE

Almost everyone these days is at least a little familiar with the multivibrator as a circuit. It is an oscillator, similar to any other in that it employs valves, and oscillates at an easily controlled fundamental frequency. It can be made to oscillate at any frequency from less than one cycle per second, to about 2 mc/sec., and has the great advantage that it contains no tuned circuits. Normally, it is used only in electronic arrangements that deal with pulses and square waves, since unlike most oscillators, the multivibrator is incapable of producing anything remotely resembling a sine-wave. Indeed, for our present purpose, it is this very fact that enables the multivibrator to be used at all. In Fig. 1 we have shown what the output of the average multivibrator looks like on an oscilloscope. The frequency can have any value within the limits indicated above, but the shape of the output wave remains substantially the same, regardless of what that frequency is. As can be seen, the output is much closer in appearance to a square wave than to a sine wave.

Now the characteristics of a square wave are very interesting. The fundamental frequency is easily seen from the shape of the wave, but it is not obvious from the 'scope picture that the output contains appreciable amounts of all the harmonics of the fundamental frequency, up to quite high frequencies. The French mathematician Fourier proved that any recurrent waveform, of whatever shape (as long as each cycle is the same as all the others) can be represented by adding together a number of sine waves. The lowest frequency sine wave needed is that of the fundamental—say 1,000

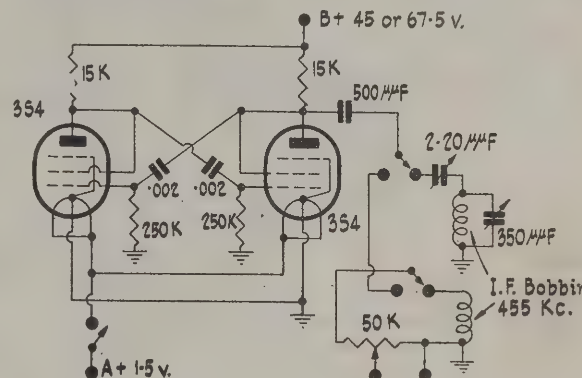


Fig. 2.—Circuit of the multivibrator signal generator. The tunable I.F. signal is modulated at the multivibrator frequency, so that no separate modulator is needed. It would be advisable to close up the spacing between the windings on the bobbin so as to increase the coupling to the untuned output winding. The 50k. potentiometer acts as an output control in both positions of the switch. There is no reason why an A.C. powered version could no be made, using a pair of small pentodes such as 6J7s, and an H.T. of 250 volts or less.

cycles, for the sake of illustration—and all the others are multiples of that frequency, or, in other words, harmonics of it. Fourier's theory says that if we take the right quantities of all these harmonics, and have them in the correct phase relationship to each other, adding them together will produce the original wave. Now although all this was first proved mathematically, subsequent work has shown that Fourier was perfectly right, in practice, as well as in theory. Conversely, if we have a peculiar wave, like our illustration in Fig. 1, it will in theory at least, actually be composed of its fundamental frequency, together with a very large number of harmonics. Suppose, for example, that the fundamental frequency is quite high—say 100 kc/sec. Then if we set the circuit going, and attach it to the aerial terminal of a radio receiver, we will actually find that the set picks up signals when it is tuned to 100 kc/sec., 200 kc/sec., 300 kc/sec., and so on. Indeed we will find that even at quite high frequencies, such as 20 mc/sec., we will still pick up signals from the

multivibrator, every 100 kc. throughout the tuning range of the receiver. And each signal will still be a harmonic of the 100 kc/sec. oscillation of the multivibrator. If the fundamental frequency were as high as this, the set would not need to be very selective in order to separate out the individual harmonics, and for some purposes, such a multivibrator is actually used. It is in precise frequency-measuring apparatus. Here, the 100 kc/sec. multivibrator is electrically synchronized with a very accurate crystal oscillator on, say, 1 mc/sec. Then, the harmonics of the oscillator give signals accurately set to 1, 2, 3, 4, etc., mc/sec., while when the multivibrator is switched on as well, up come signals at 1.1, 1,2, 1.3, etc., mc/sec. The process can be carried even further by locking a 10 kc/sec. multivibrator to the 100 kc/sec. one, whereupon signals appear accurately spaced every 10 kc. throughout the radio spectrum. In this case, however, the radio receiver would need to be quite selective in order to separate the individual 10 kc/sec. harmonics from each other.

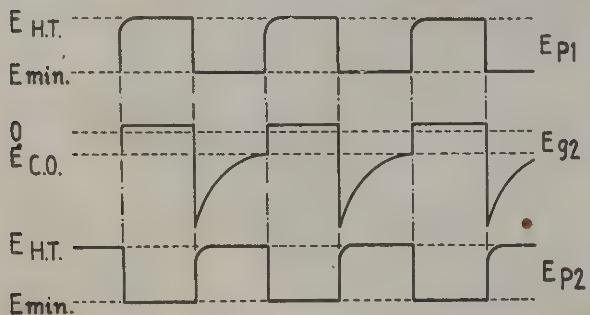


Fig. 1.—Waveforms obtained from a multivibrator. The top and bottom ones are at the plates of the valves, while the middle one is that at one grid.

If we have a multivibrator oscillating on an even lower frequency, such as 5 kc/sec.—actually inside the audio range—it will still produce output on its very high harmonics, and it will be possible to pick up these harmonics on a radio set. But the ordinary radio set is not selective enough to be able to split these R.F. carriers (for that is what they are) and wherever the set is tuned, several of them are received at once. The effect, therefore, is simply that of a continuous noise, which can be picked up wherever the tuning control of the receiver happens to be set. This is the basis of the alignment multivibrator. It is a simple multivibrator, operating on a fundamental frequency of from 5 to 10 kc/sec. Its harmonics are so violent that even the very high ones (as high as the 1,000th) are great enough in amplitude to be picked up by a quite insensitive radio set. If the set is to be aligned, therefore, we turn on our multivibrator, and are immediately provided with signals all over the broadcast and short-wave bands without even the necessity of having to tune anything but the set we are aligning.

At first sight, this might not seem a very useful sort of signal generator to have, but the only "catch" is in knowing how to use it. In conjunction with the ordinary radio stations, it enables the signal and oscillator circuits of a set to be properly aligned, just as properly as if we had used an expensive standard signal generator, in fact, and in certain respects much more easily and quickly.

HOW IT IS USED

In the first place, let us take the simple case of a set that has once been in alignment, and simply needs adjustment in order to restore the proper adjustments, that have drifted out during the passage of time. The I.F. amplifier, we will assume, is near enough, and has been "tweaked" up on one of the stations, so that its circuits are all adjusted to the same frequency. The set is then turned on, and the dial set to 1400 kc/sec. The multivibrator is turned on, and connected to the aerial terminal of the receiver. When the volume control is turned up, a loud buzzing noise is heard, sounding like all the interference that ever was. The aerial and R.F. trimmers can now be adjusted for loudest output. Next, the set's dial is turned round to 600 kc/sec., the usual place for adjusting the padder, and *without touching the gang condenser,* the padder is now adjusted for loudest output. This is all there is to it. With a normal signal generator, adjusting the padder is a matter of watching the output on an output meter, and adjusting the padder while rocking the gang back and forth, until the best combination is found. All this is eliminated with the multivibrator, and after the simple adjustment of the padder, all that has to be done is to see whether stations come in at their correct dial settings!

This brief description will indicate how extremely simple the business of lining up a set becomes with the multivibrator as the only test instrument, provided the set is somewhere near alignment before we start. If it is not, the procedure is a little more complicated, but not much, and the multivibrator still enables the right answer to be found.

THE CIRCUIT

As the diagram, Fig. 2, shows, the circuit is simplicity itself. The multivibrator uses two 3S4 valves. It would have been preferable to employ a double triode, such as the 1G6-G, but as these are in short supply, it was thought preferable to put in the additional valve and make sure that would-be builders will not have difficulty in obtaining the specified types. The 3S4s are triode connected, since the added complication of working them as pentodes was not warranted by the production of any better results.

After all the introductory remarks about the mutlivibrator itself, readers will no doubt wonder what the tuned circuit is for. The necessity for an additional tuned circuit has nothing at all to do with the multivibrator itself, but is concerned with the alignment of the I.F. amplifiers of receivers. When a receiver is to be lined up, the first necessity is to see that the I.F. amplifier is aligned on the correct frequency. We have heard of home builders who have not even touched the I.F. transformers after the set has been completed, relying on the maker's statement that the transformers had been adjusted to frequency before leaving the factory. It is quite possible for such a course to be successful, but it is not likely to succeed in all cases. Not that we doubt the veracity of the maker of the transformers. The trouble is that it is very unlikely that the stray capacities built into the set in which the transformers are used will be the same as those in the maker's test rig, so that although the alignment cannot be very far out, as long as the trimmers have not been touched, it will still be necessary to make small adjustments to bring the circuits exactly into line. For this purpose, the normal procedure is to use a signal generator, and set it to the I.F., usually 455 kc/sec. It is fed into the grid of the oscillator-mixer valve, and all I.F. trimmers are adjusted for maximum output from the set. Accordingly, the present instrument really needs some means of setting the I.F. trans-

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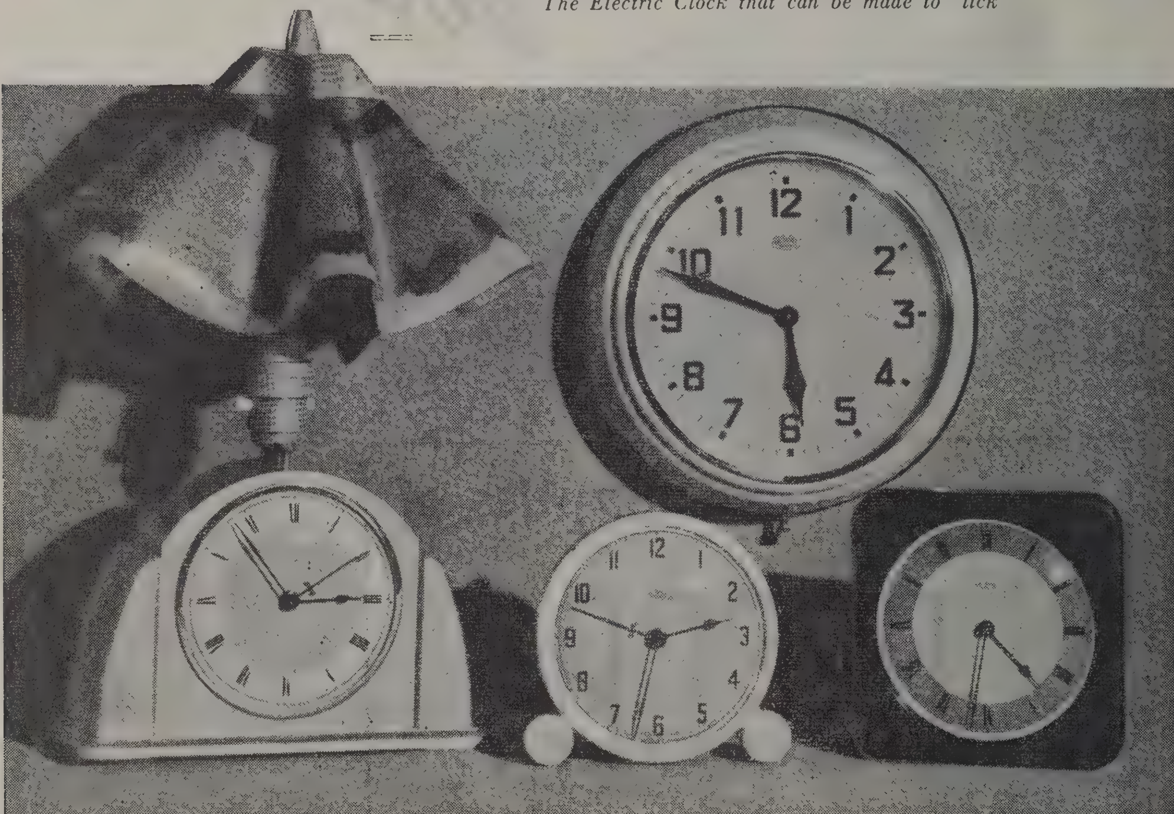


formers to 455 kc/sec. One way of doing this would have been to incorporate a separate C.W. oscillator on this frequency, which could be switched on when needed. Unfortunately, this would also necessitate a separate audio oscillator, with which to modulate the I.F. oscillator, and the whole contrivance would take on the appearance of a fairly complex piece of equipment. Instead of this, we have made use of the multivibrator once again. This arrangement shock-excites the tuned circuit once every four-hundredth of a second, so that the circuit produces a damped train of waves at its own frequency. The circuit is not an oscillator in the ordinary sense of the term, as it is kicked in and out of oscillation 400 times a second, but the effect is the same as if we had a C.W. oscillator modulated at 400 cycles per second with a very rough sort of tone. Thus, in order to align I.F. amplifiers, all that has to be done is to throw the swtich over to the "I.F." position, and take the output to the set from the I.F. output terminal. Of course, it is necessary to have had the frequency of the coil adjusted to the right value beforehand, but this is only a matter of seconds to do, by feeding it into a set which is known is have been aligned on 455 kc/sec. already. It can now be seen that the instrument is fully capable of aligning 455 kc/sec. I.F. amplifiers as well as the signal circuits.

ALTERNATIVE VALVES

If you should have any alternative valves that you would rather use than the 3S4s, there is no reason why this should not be done. The circuit is not in the least critical in regard to valve types, and almost any small triodes will do for the multivibrator. It would be advisable, however, to stick to the 3S4 for the pulse amplifier tube which feeds the 455 kc/sec. tuned circuit. We have shown the gadget as a battery-operated one, because it can be extremely handy to have a signal source that does not depend on the A.C. mains. For example, it could be an extremely useful adjunct to the country serviceman's kit of equipment, and indeed, to any serviceman's. It can be constructed in a very small space, and thus will be much handier to carry out to jobs than a conventional signal generator. It can also be built for a very modest sum, and should not strain anyone's pocket-book.

Should anyone wish to make up an A.C. powered version, the modification will obviously be very slight.

H.T. voltages up to 250 can be employed, as the current drain is only a few milliamps, and power can be taken from any handy source, such as that of an existing amplifier or receiver. If a separate power supply is to be built for the instrument, a 30 ma. 150v. a side power transformer is suggested, while a smoothing filter consisting of a single 16 μf. electrolytic will be ample. There is no point at all in having a highly smoothed supply for a device like this.

USE WHERE THE SET IS BADLY OUT OF ADJUSTMENT

The simple procedure given in an earlier paragraph will not quite do for the case of a set that has just been built, and where it is not known how far out of adjustment it is. The first step, of course, is to line up the I.F. amplifier. This is done in the usual way, using

(Concluded on Page 48.)

Drawing Curves on the Oscilloscope

The oscilloscope has always appeared to be well adapted to the problem of automatically tracing curves, such as the characteristics of valves, and has actually been put to use commercially in this capacity. Most curve-tracers, however, are highly complicated, and outside the scope of all but the large laboratory to build. The equipment to be described in this two-part article is simple enough to be built by anyone who has an oscilloscope, and will be of particular interest to those who have built their own 'scopes.

INTRODUCTION

It has always seemed a little surprising to the writer that by far the greatest use that is made of that extremely versatile instrument, the cathode ray oscilloscope, is concerned only with the display of waveforms. These pictures are curves, in the mathematical sense, and are graphs showing how a voltage or current varies with respect to time. As everyone knows, a waveform is displayed by the simple process of putting the alternating voltage to be examined on the Y deflecting plates of the cathode ray tube, and placing on the X deflecting plates a voltage that sweeps the spot across the screen at a uniform rate. The later volatge is of a saw-tooth shape, and in general is known as a time-base. The name is one that we all know, and which we take for granted to such an extent that its real significance tends to be lost. It means what we have expressed in words above, namely, that it forms a time scale in the horizontal direction, and enables us to see how the voltage on the Y plates varies as a function of time.

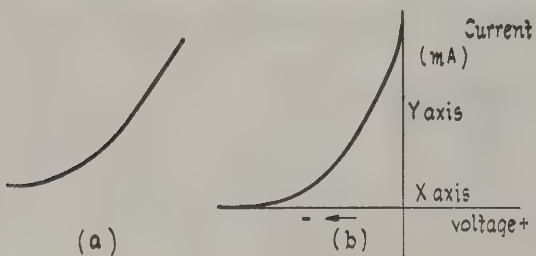


Fig. 1

While it is true that waveforms constitute an exceedingly large and interesting class of graph, that is of very great use in all work which deals with alternating currents and voltages, it is sometimes forgotten that a waveform is only one class of graph, and that there are others.

All of us make great play with valve handbooks, with their many curves illustrating the performance of the valves under specified conditions. None of these curves have a time basis. They are curves showing how the plate current varies when the plate voltage is held constant and the grid voltage is varied, or curves showing how the plate current varies when the grid voltage is held constant and the plate voltage is varied, and so on. Now the oscilloscope is just as suitable for displaying these curves as it is for showing waveforms, and it would seem that the chief reason why comparatively little use is made of the 'scope for these purposes is simply that it is not quite so easy to make the oscilloscope produce these curves. For example, take the mutual characteristic of a valve. This is the one in which the plate voltage is held constant, and the plate current is plotted against the grid voltage. Suppose we are faced with the problem of showing this curve on the screen of our C.R.T. It is a simple matter to set up a valve with a certain fixed plate voltage, and to supply an alternating voltage to the grid. It is still a simple matter to put the same voltage on the X plates of the C.R.T., so that deflection in the horizontal direction represents the grid voltage, but when we come to decide just how we are to make the plate *current* produce a vertical deflection on the scope, things are not so easy. The obvious answer is to use deflecting coils for the Y deflection, instead of using the deflecting plates. The the coils are placed in series with the plate of the valve, and the actual plate current flows through them. In this way, the deflection in the Y direction should be proportional to the plate current, and we have our curve on the screen.

Unfortunately, there are a few things that make this simple solution far from ideal. In the first place, if the valve is a small one (as it well may be) so that the plate current is only a few milliamps, a coil of very many turns will be needed in order to produce a worthwhile deflection on the screen. This coil will have resistance and inductance, and since we are attempting to draw the curve of the valve itself, without any load impedance, the existence of the coil will alter the plate current that we are trying to measure, and so will not give a true answer. Iron-cored deflecting coils would not be be any better, because although the resistance would be less, the impedance would be still greater, and the curve would still not be a true one. So we try again. What about putting a large resistance in series with the plate circuit, as in a resistance-coupled amplifier? The voltage across this resistance will be proportional to the plate current, and will be an amplified version of the grid voltage. Unfortunately, this will not do either, because the presence of the load resistor will still modify the curve, and although the result will be a true representation of the valve *with its load resistor,* what we want is a true representation of the valve itself, without load resistor. This looks pretty much like a dead end, but it is not really. Suppose instead of the large resistor, we put a very small one, say 1000 ohms, or even smaller. This resistor is very small compared with the plate resistance of the valve, and its presence will not modify to any appreciable extent the current that flows in the plate circuit. So far so good. The small resistor will have a small voltage developed across it by the plate current, and this voltage can be taken as accurately proportional to the plate current. It will not be nearly big enough to deflect the spot of the cathode ray tube far enough for us to get a reasonably-sized picture however, but we can overcome this by interposing an amplifier between the valve being investigated and the deflecting plates of the scope. With the amplifier, we can make the Y deflection as large as we please, so that it will not be difficult to obtain a large enough picture to look at or photograph.

This gives us our curve, as shown in Fig. 1. But such a curve is not a great deal of use unless it has the axes marked on it. No one ever drew a curve that was meant to be used without putting in the axes, and marking on them the scale of units that is needed if the graph is to be read. So far, our cathode ray curve tracer is interesting, in that it has drawn the curve required, but not very useful unless we can calibrate it. One way of doing this would be to place over the face of the C.R.T. a squared graticule, but this would not be very satisfactory in practice because we still would have no means of telling how many volts the X scale represented, or how many milliamps the Y scale represented. This difficulty need not be insuperable, however, because it is possible to measure the actual circuit voltages with meters, and then if the gain of the Y amplifier is not changed, we know that so many inches of deflection, on either axis, represents so many volts or milliamps. The use of a graticule, though, demands considerable care on the part of the operator, for once the whole system is set up, it only needs one of the gain controls, or one of the shift controls of the scope to be shifted inadvertently to ruin the calibration, and make it necessary to do it all over again.

A much better idea than the graticule is to make the cathode ray tube draw its own axes on the graph, automatically. If this is done, all that is needed is a ruler, in order to get reading in actual figures from the resulting picture. Of course, it is still essential to see that none of the controls have been altered, but the setting up procedure is much simplified, and it is possible to build in simple calibrating devices which will show at a glance whether the settings have been tampered. Needless to say, if the scope draws its own axes, the setting of the scope's shift controls does not matter, and the need for supervising these controls no longer exists.

HOW THIS IS DONE

It is all very well to say "make the scope draw its own axes," but how is this to be done. Some form of automatic switching is necessary, and those who have seen or tried to build the circuit of a simple electronic switch will realize that the switching necessary to enable this to be accomplished must, of necessity, be quite complex if electronic means are to be employed. Valves could certainly be used, and there would not be any very great difficulty attached to building the necessary circuitry, but the device, once built, would hardly be inexpensive enough to interest many amateur experimenters. Valve factories have developed for their own use exceedingly complex curve tracers, which not only draw one curve, and put in the axes, but draw a whole family of curves, such as the complete characteristics of a valve, comprising a dozen or more curves, all seen on the tube at the same time. But if we forego the delights of making our curve tracer all-electronic, and descend to the level of using mechanical devices, then it is possible in a very simple piece of apparatus to draw one curve and its axes. We mentioned a little earlier that interested amateur experimenters might like to try their hands at a cathode ray curve tracer, but there is no reason why an equipment like the one we will describe in this article should not be built as a production testing unit, and used by receiver manufacturers and others who find it necessary to have rapid and accurate checks on the condition of valves. Once the unit is set up for a particular valve type, it would be possible to draw on a transparent mask the curve of a "bogy" valve, and the comparison with this curve of the one given on the C.R.T. would enable valves to be tested as quickly as they will heat up.

AN ORDINARY VIBRATOR

In the common or garden vibrator, used as a means of producing A.C. from D.C., we have an excellent automatic switch. If it is a type with a separate driving contact, and is also a "synchronous" one, it possesses two sets of change-over contacts, that we can perform switching actions with, at a rate of just over 100 times

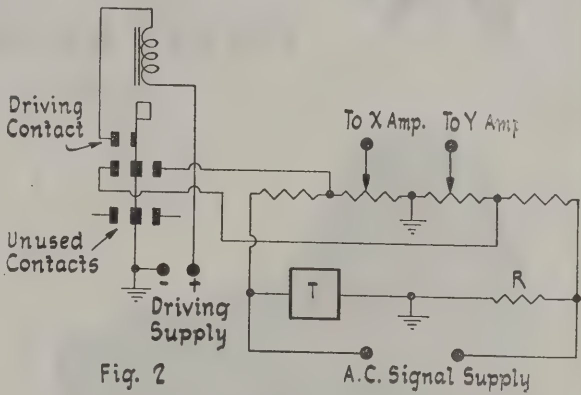


Fig. 2

a second. For some purposes, of course, the vibrator is far from ideal, but for the present job, for which it seems to have been first suggested by A. H. B. Walker, in *Wireless World*, September, 1944, it is ideal, although a little adjustment made by found necessary. The basic circuit is shown in Fig.2. A synchronous vibrator is shown, driven, not in the normal way, but in the same manner as an ordinary electric bell or buzzer, by putting the coil in series with one of the normally made contacts. This contact, and its mate are not used in the switching operation at all. The other pair of contacts are arranged to short-circuit the inputs of the two deflection amplifiers. They do this alternately, since the reed can dwell on only one of them at a time. The sequence of events is as follows. While the reed is travelling between the two contacts, neither amplifier input is short-circuited, so that both function normally, and part of the curve is traced. When the reed reaches the contact that short-circuits the Y amplifier input, this amplifier receives no signal, and the spot is no longer deflected vertically. But the X deflection amplifier is still working, so that as long as the contact shorts the Y input, the spot traces a horizontal line through the position of rest of the spot (*i.e.*, the origin of the curve). It therefore moves along the X axis. Then, the reed leaves its contact, and travels in the opposite direction. While doing so, both amplifiers function, as before, but when it reaches the other contact, it this time short-circuits the input to the X amplifier, so that while contact remains, the spot moves only along the Y axis. As long as the frequency of the signal is either considerably higher or lower than the frequency of the vibrator, then the overall result is that the curve, and both axes, appear on the screen. However, the action of the spot in building up the picture is rather different in the two cases. Suppose, for example, that the frequency of the test voltage is 50 c/sec., and that the vibrator frequency is 120 c/sec. In this case, the action is represented by Fig. 3, where the sequence of events, as described above, can be seen occurring. It will be noted that the vertical and horizontal portions which represent the sudden transitions from contact to no contact, and

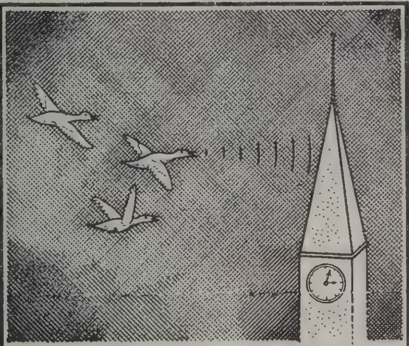
(Continued on Page 41.)

Introduction to Radar Techniques

Part I.—The Radar System

By the Engineering Department, Aerovox Corporation

The use of Radio Detection and Ranging, more commonly abbreviated "RADAR," played an important part in determining the outcome of World War II. Although overshadowed in the final stages of the hostilities by the more spectacular atomic bomb, few military tacticians doubt that radar played a more decisive role in securing Allied victory. Even more important is the fact that this electronic instrument is finding an ever-widening sphere of usefulness in peace-time applications. Radar has become a permanent part of the field of radio, not only as a dependable aid to marine and airborne navigation, but also as a valuable adjunct to meteorological stations throughout the world. Its use as a traffic control device for measuring the speed of automobiles travelling on highways has also been announced. Such uses are only a few of the many which will ultimately be found for this principle. Radio technicians in coastal areas have already found a lucrative field of endeavour in the installation and maintenance of marine radar equipment on fishing boats and ferries. In short, radar has emerged from the laboratories and military field of operations and has become a part of the everyday civilian scene. For these reasons, this article, as well as several succeeding ones, will be devoted to a discussion of the fundamental principles of radar. This series will be interspersed from time to time with articles on other subjects of a timely nature to maintain variety.



EARLY AIRBORNE RADAR

FIG. 1

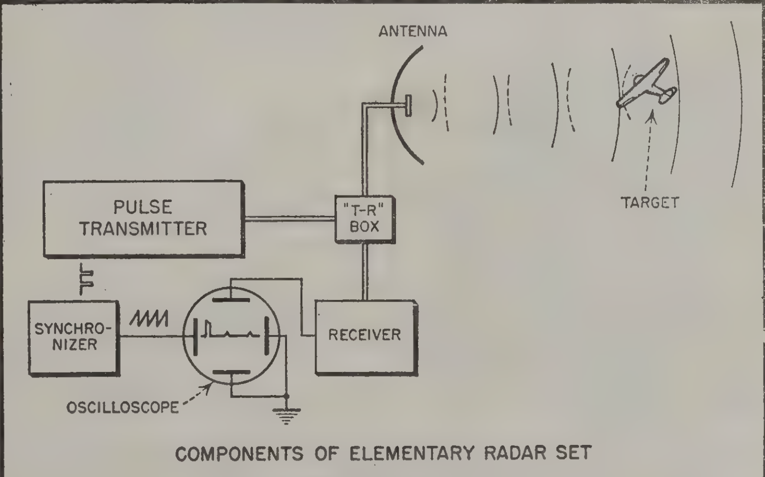
HISTORICAL NOTES

Historically, the use of the basic radar principle, *i.e.*, the detection of surrounding objects or obstacles by echoes reflected from them, is not new. In nature, the radar system has been used for as long as wild geese and other migratory birds have navigated through darkness and overcast by "honking" or making other sounds whose echoes warn of approaching obstacles. See Fig. 1. Bats, too, are credited with masterful blind navigation by uttering a series of short, supersonic squeaks and interpreting the echoes from these in terms of range and bearing information. Man has utilized the same scheme to some extent in navigating rivers and harbours. Old skippers of ferries, river boats, and coastwise steamers have been known to develop a remarkable faculty for determining their bearings despite fog or darkness by listening to distinctive echoes of the boat's whistle bouncing off shore lines or passing craft. Many such men of long experiences and practiced ear claim to be able to differentiate between rocky or wooded coast lines, as well as glean a good estimate of the size and type of a passing vessel, by the nature of the returned echo.

The first use of electronic radar is attributed to Watson-Watt in England, in 1935, although the technique of detecting the echoes of short pulses of radio frequency and energy had been used much earlier (1925) by Breit and Tuve to measure the height of the ionosphere. This work suggested the possibility of obtaining echoes from aircraft and other objects smaller than the ionosphere to a score of workers in several major countries. As a result, successful radar systems were developed almost simultaneously during the late thirties in France, England, Germany, and America.

THE BASIC RADAR SYSTEM

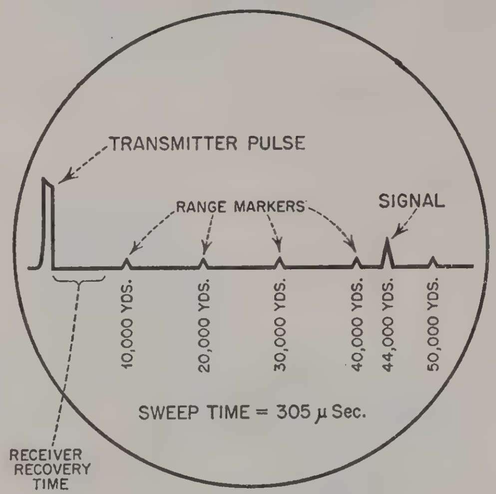
The fundamental elements of a radar system are shown in Fig. 2. Very short pulses of radio frequency energy which recur at regular intervals are generated by the transmitter. These intense "bursts", which may be only one *millionth* of a second in duration, are radiated by the antenna in a narrow beam. These waves propagate through space with the speed of light and, upon striking a reflecting object, are returned to the receiver as an echo. The output of this receiver is connected to the vertical plates of an oscilloscope. The horizontal plates of this 'scope are driven by a linear, saw-tooth sweep



COMPONENTS OF ELEMENTARY RADAR SET

FIG. 2

generator which is synchronized with the transmitter pulses in such a manner that the sweep starts across the face of the 'scope at the time of each transmitter pulse. Received echoes then form small vertical "pips" on the base line which represent reflecting objects at distances indicated by their positions on the time base. See Fig. 3.



DETAILS OF "A-'SCOPE" PRESENTATION

FIG. 3

Since radio waves travel in space at a constant velocity, the range of a target indicated on the display oscilloscope may be accurately determined by measuring the time elapsed between the transmission of a pulse and the reception of an echo. This is easily done since the 'scope sweep is linear with time and so can be calibrated directly in range. The range of a target in yards is thus related to the echo time by:

$$\text{Range (yds.)} = \frac{327.5\,t}{2} \qquad (1)$$

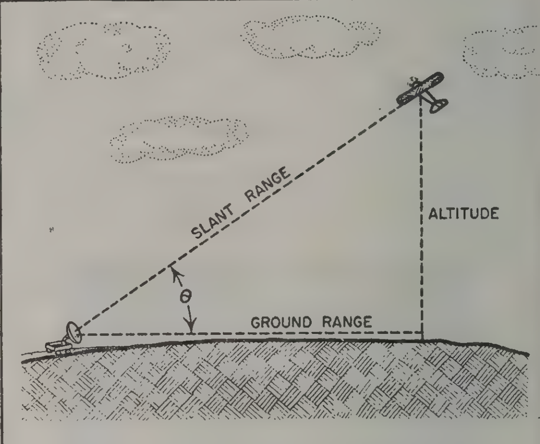
Where: t is the echo delay time in microseconds (μ sec.)

327.5 is the free-space velocity of radio waves (yds./sec.)

Note that the distance travelled by the waves (velocity times time) is divided by the factor 2 for the actual radar range, since the waves must travel this distance twice, going to the target and returning.

To facilitate measuring range, the time base is frequently provided with *range markers,* as illustrated in Fig. 3. These range calibration points are formed by feeding a pulse signal into the vertical deflection plates. The repetition rate of these pulses is chosen to correspond to time intervals which represent convenient increments of range, such as 5,000 or 10,000 yards. Markers of this type ensure accurate ranging, even when the time base departs from linearity.

The angular bearing, or *azimuth,* of the target is determined by the directional position of the antenna. Information on the elevation of aircraft is obtained in the same manner. The range indicated in this case is called the "slant range." The ground range and altitude are then obtained by simple trigonometry, as shown in Fig. 4. The accuracy of these measurements is limited by the beam width of the antenna pattern. In practice, beam widths of less than one degree are achieved by using large, highly directional antennas and very short operating wavelengths.



ALTITUDE = (SLANT RANGE) (Sin θ)
GROUND RANGE = (SLANT RANGE) (Cos θ)

FIG. 4

Although some radar sets have used separate antennas for the functions of transmitting and receiving, the arrangement illustrated in Fig. 2 is much more convenient. Both transmitting and receiving is done with the same antenna by using a system of automatic switching known as "duplexing." By this method, the receiver is effectively disconnected from the common transmission line during the "on" time of the transmitter and so is protected from overload and burnout damage by the high power transmitter pulses. Between transmitter pulses, the receiver is automatically connected to the line and the transmitting tube is isolated to prevent its absorbing some of the received signal. Duplexing is usually accomplished by using a gas-filled switching device known as a "transmit-receive tube" or, more simply, a "T-R box." The functioning of duplexing devices will be more fully discussed in a subsequent issue.

The method of displaying information illustrated in Fig. 3 known as an "A-'scope" presentation, is only the simplest of many possible types. Although used universally on early radar equipments, it was soon replaced or supplemented by more advanced kinds. One of the most useful of these is the *Plan Position Indicator,* or "PPI," depicted in Fig. 5. This type displays a map of the terrain surrounding the radar set in polar coordinates, with the set at the centre of the oscilloscope face. To do this, a radial sweep originates at the centre of the tube and is rotated angularly about this point in synchronism with the position of the antenna, which is continuously scanned in azimuth. Received signals are used to intensity modulate the electron beam so that a bright spot is "painted" at the range and azimuthal position of each target. The use of long persistence phosphors enables the 'scope to retain these images until renewed by another antenna scan. The radial sweep is

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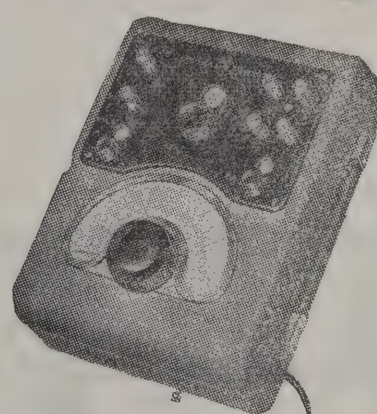

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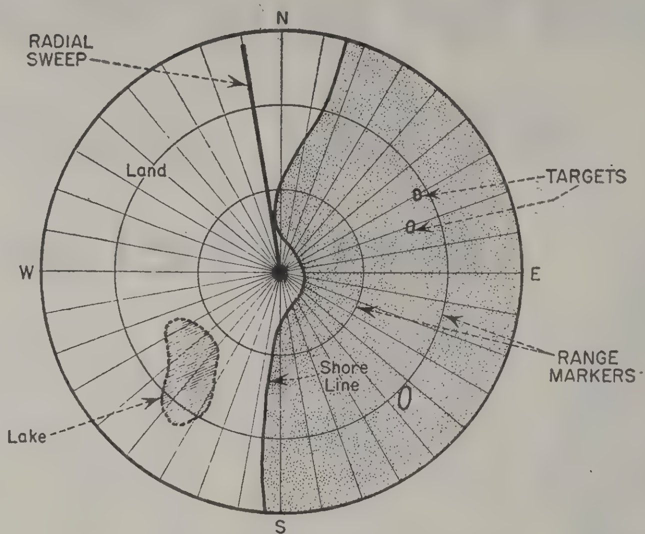


TYPICAL "PPI" PRESENTATION

FIG. 5

The maximum range obtainable from a radar set of a given design depends upon such factors as transmitter power, size of the target, gain of the antenna, sensitivity of the receiver, operating wavelength, etc. These factors have been related by what is commonly called the "radar equation."

$$R_{max} = \sqrt[4]{\frac{P\sigma A^2 f^2}{4\pi S_m \lambda^2}} \qquad (2)$$

Where:

R_{max} is the maximum range in miles
P is the peak transmitter power (watts)
σ is the reflecting area of the target
A is the antenna aperture (sq. ft.)
f is an antenna illumination factor (between .5 and 1.0)
S_m is the minimum signal the receiver will detect (watts)
λ is the operating wavelength (ft.)

produced by a rotating electro-magnetic deflection system which is synchroninzed with the antenna angle by an electrical or mechanical linkage. Presentations of the PPI type are especially useful for navigational radar.

LIMITS OF RADAR PERFORMANCE

The range of a radar equipment is determined by many design factors. The minimum range at which a target may be detected is limited by the duration of the transmitted pulse and the *recovery time* of the duplexing system. If the transmitted pulse is too long, echoes from objects at close range will be returned while the transmitter is still operating and the receiver is blocked by the TR system. Since the TR tube requires a finite time to recover after each pulse is sent, the receiver also remains inoperative for a short time after the completion of the pulse. The result is a "blind spot" in the immediate vicinity of the radar set which is usually of little consequence, since long range operation is the most important in most applications.

By means of this relationship, radar system designers can reasonably predict the performance of a proposed equipment. Note that the range varies as the *fourth* root of the other factors. This arises since the signal traverses the path twice, so that the received signal is inversely proportional to the fourth power of the distance rather than the familiar inverse square law of one-way transmission. For this reason, very high transmitter powers and very sensitive receivers are needed for satisfactory radar operation. Fortunately, the pulsing technique required for ranging also makes possible the generation of peak powers of far greater magnitude than could be obtained by continuous wave oscillators. Pulse powers of hundreds of kilowatts are in common use. Subsequent articles of this series will discuss means of generating and radiating such energy.

SHOES and SHIPS

"The time has come," the Walrus said,
"To talk of many things. . . . "

By Special Arrangement with the Walrus

CHASSIS LAYOUT

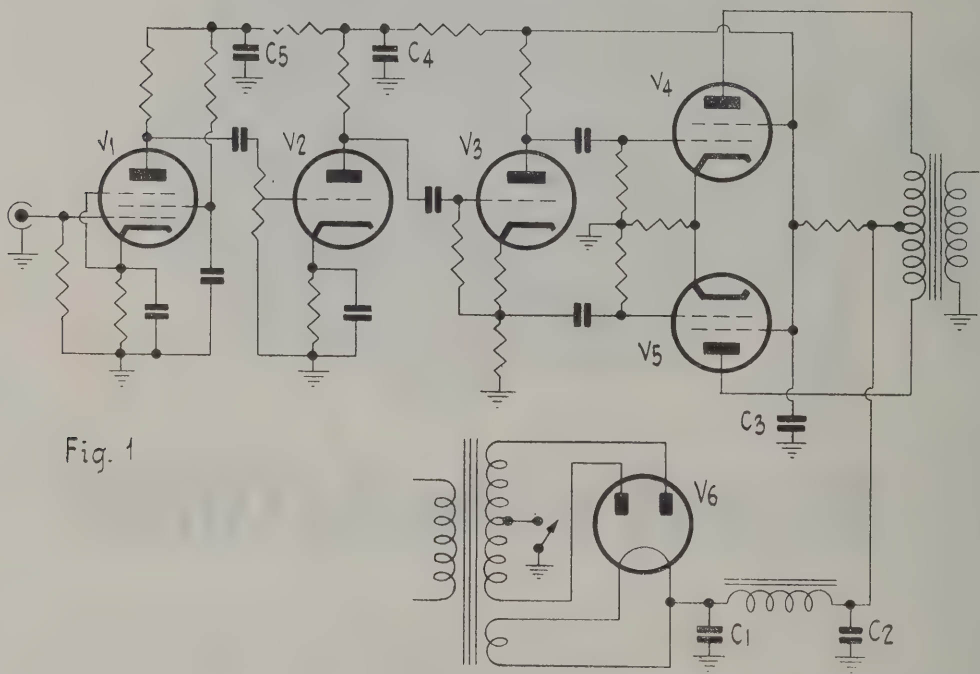


Fig. 1

The best methods to adopt in laying out a chassis, either radio or amplifier, has proved a stumbling block to many a young enthusiast and also to older and more experienced people who should know better. Now, although something has been said in previous articles of "Shoes and Ships" along these lines, it appears there is room for much more elaboration of this theme.

To begin with, the first thing to be done is to obtain all the major components necessary for the construction of the unit—by that we mean all the parts to be mounted on the chassis. Don't, if you can avoid it, try to lay out the chassis without certain components under the assumption that they will be obtainable anyway. Frequently these days when one comes to get various parts it is only to find that they are out of stock, it may be only temporarily, but it can be very inconvenient and generally leads to improvization in having to adapt less suitable parts to do a specfic job. With all the components on hand then, the next point is what to do about a chassis; either it will be a ready-made one or home fabricated to suit. In the first case, you are committed to a definite size and the parts must be laid out accordingly. In the second case you can let your fancy run free and do just what you want within the bounds of good radio practice.

In the latter case, take a piece of brown paper, or similar material, and use that to lay out your design so that when you have a good arrangement the chassis boundaries can be marked off and transposed to the sheet metal.

In the construction of an audio amplifier, the components should be distributed in such a manner that all hum inducing parts are placed at a maximum possible distance from the input circuits where greatest amplification takes place and which are consequently more subject to hum pick-up. All valve sockets should be oriented in such a way as to keep their grid and plate leads as short as possible and all decoupling electrolytics need to be placed close handy to the valves they serve. It is very nice to be able to distribute all your valves in a straight line along the chassis and to arrange the other components in a precise geometrical pattern, but generally it is wiser to compromise a little with practical perfection for the sake of electrical convenience. The one does not excuse the other, however, and it should be quite possible to have a neat top layout and a good electrical symmetry.

Fig. 1 shows a straightforward audio amplifier with no tricks attached to it, and Fig. 2 depicts one possible neat and practical layout.

It can readily be seen that the power transformer and filter choke—both units surrounded by strong hum fields —are situated as far as the chassis permits from the input and pre-amplifier V_1. The rectifier, V_6, is well away too, and is close handy to the power transformer. The output transformer is well positioned with respect to the output valves and also imposes its mass between the power transformer and V_1, thus providing additional

screening. C_5 is conveniently placed for V_1, C_4 for V_2, and C_3 for the screens of the output valves V_4 and V_5. C_1 and C_2 are not particularly critical and fit in nicely in that position. There can be many variations to this layout which may perform just as well, but they must all conform to the rules for good design in order to achieve the right results. The same thing applies in an

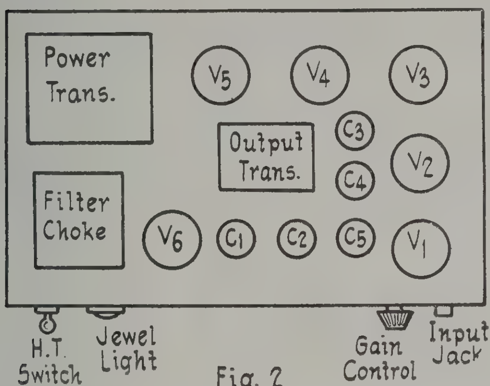


Fig. 2

ordinary radio set, not perhaps so much in the audio end which is of comparatively low gain, but more specifically in the R.F. and mixer end. Place coils, gang condenser and valve sockets with a view to cutting down length of grid and plate leads and at the same time taking advantage of any natural shielding tendencies. Where unshielded aerial and R.F. coils are used the writer has found it very much to advantage to place them in opposite planes to reduce coupling and so interaction between them, *i.e.*, one in the horizontal plane and the other in the vertical. Arrange the chassis so that the audio end is well away from the R.F. end and so that the first valve feeds into the second and thence into the third via the coils with a minimum of connecting lead. Finally, it is no overstatement to say that once the fundamentals of good layout are appreciated, one's chances of success with radio apparatus are greatly enhanced.

After a while it becomes second nature and the old stager will unconsciously shy clear of bad positioning where the less experienced would not think twice, which accounts for the aforementioned gentleman's greater good fortune in the results department!

The PHILIPS Experimenter

An advertisement of Philips Electrical Industries of N.Z.,Ltd.

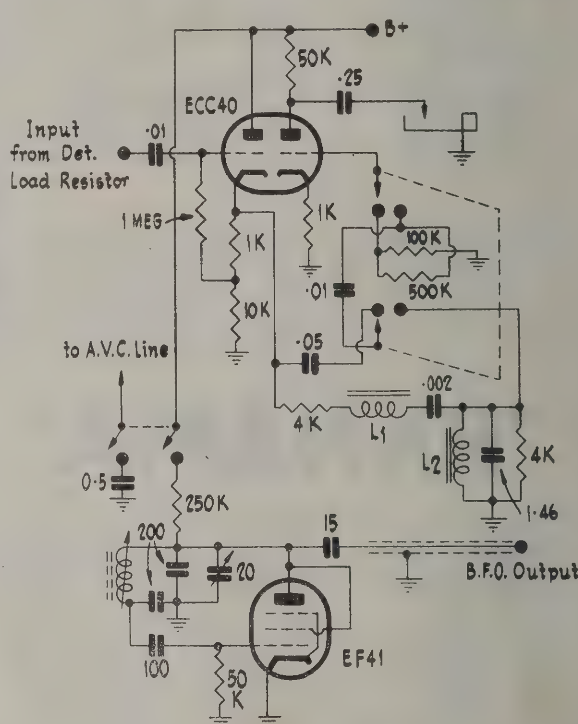
No. 59: Super-Selectivity Without Tears—Part III

So far, in this series, we have described in detail the super-selective I.F. amplifier stage and the additional circuits needed to make it into a practical I.F. channel for a receiver, up to and including the second detector and A.V.C. valve. For C.W. work, in which the circuit will probably find its greatest use, it is necessary to include a beat frequency oscillator, and, at the same time, we have promised readers that we would include a circuit for a highly selective audio filter, which can be used to supplement the selectivity of the I.F. channel. We have accordingly drawn these portions separately from the main I.F. amplifier, realizing that many readers will not want to build the whole thing exactly as we have described it, but will rather prefer to cull from it the portions in which they are specially interested. For example, there is no reason why the circuit of the audio amplifier and audio filter cannot be taken and used with any other type of I.F. amplifier and detector circuit. Similarly, those who wish may easily pick out the super-selective I.F. stage and build it into an I.F. amplifier which is otherwise of their own devising. We would like to emphasize once more that we do not pretend that the full circuits of these Experimenter articles must be adhered to in every detail. In order to properly try out a new idea, it must be incorporated in a relatively complete piece of equipment, and, in the present case, the remainder of the circuit, after the main featured portions have been taken out, can be altered to suit builders' individual tastes.

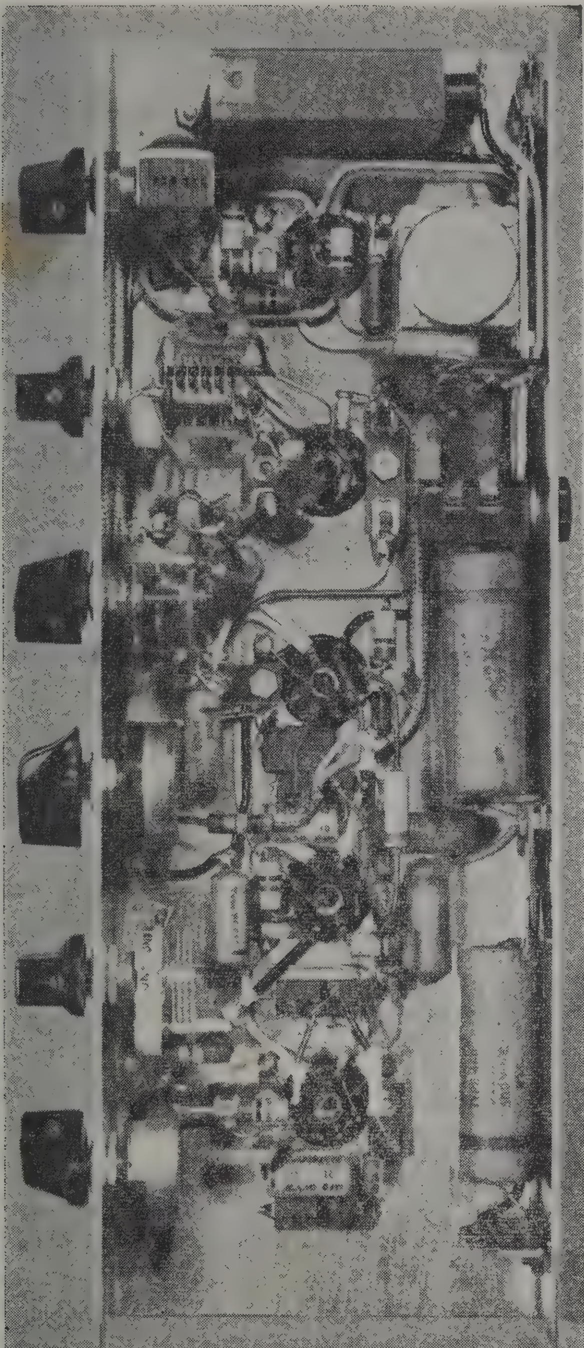
THE AUDIO FILTER

The filter proper consists of two chokes and two condensers. The chokes are labelled L_1 and L_2 respectively, and the condensers are the 0.002 μfd. in series with L_1 and the 1.46 μfd. in parallel with L_2. Unfortunately, however, it is a difficult matter to build a filter of this kind in such a way that it can be simply inserted into an existing audio amplifier. For this reason, a Philips ECC40 valve has been used in conjunction with it. Just why the two sections of a double triode are necessary will shortly be explained. The first section is connected as a cathode follower, which feeds the input terminal of the filter. The output of the filter is taken to the second section of the Philips ECC40, which is a conventional resistance-coupled amplifier, which can excite a pair of headphones directly, or which can be fed to a conventional power output stage for loudspeaker operation.

The two ganged switches substitute for the filter a simple resistance-capacity network for the grid of the amplifier section, and enable the filter to be cut out of circuit when it is not needed. Filters such as this one have to be designed for a particular bandwidth, and for a specific input and output impedance, if they are to be satisfactory in performance. In theory, at least, it is possible to design the filter for any desired terminating impedance, but there is a practical limit, which is set by the fact that, as the impedance is raised, so does the value of one of the chokes reach impossibly high figures. For the filter to be a good one, the Q of the chokes must be high, and it is a very difficult matter to build high-Q



chokes of high inductance. Philips Ferroxcube, which is probably the best core material yet developed for high-Q chokes at audio frequencies, has enabled us to get quite a high inductance with a Q of over 50 at 1,000 cycles per second, and this, in turn, allowed the filter to be designed for terminating impedances of 4,000 ohms. Even so, this figure is by no means high enough to enable the filter to be connected between the plate of one valve and the grid of the next. To do this, and still retain a resistance-coupled amplifier stage with normal characteristics, it would be necessary to design the filter for an impedance of at least 25,000 ohms, and this would need an inductance of some 56 henries. It would probably have been possible to achieve this had one of the large Philips pot-type Ferroxcube cores been used, but as these



are rather expensive for amateur use, it was decided to stick to some arrangement that would be practicable using the small pot-cores shown in the under-chassis photograph. The 13.9 henry choke was made by winding 2,400 turns of 42-gauge enamelled wire on to the small plastic bobbin that is sold with the cores. Incidentally, these cores are sold complete with the bobbin and the brass cover plates, so that mounting is no difficulty. The other choke, L_2, needs only 18.3 millihenries, and thus consists of only 72 turns of 30-gauge s.c.c. wire.

Since the input impedance of the filter is so low, it is necessary to feed it from a cathode follower, and this accounts for the presence of the latter. At first sight, it might appear as if the terminating impedance at the input end of the filter is not 4,000 ohms at all, but 15,000. This appearance, however, is only an illusion, because, when the cathode follower is functioning, the impedance to earth of the cathode terminal is of the order of $1/g_m$, which in this case is approximately 500 ohms. Thus, the actual terminating impedance is 4,500 ohms. If desired, the 4,000 ohms resistor could be changed to 3,500, giving a closer impedance match, but in an application like this one, extremely accurate matching is not essential by any means. The cathode follower effectively feeds the filter at a 500-ohm tap on a 4,500-ohm load resistor, so that there is considerable loss of signal level at the output of the filter. This does not matter, however, because it is more than made up for in the succeeding amplifier stage. It does make one practical difference, though, because, when the filter is cut out of circuit, there would be a large increase in signal volume were not something done to prevent it. If the coupling circuit between the cathode follower and the amplifier is traced through, it will be seen that, when the filter is not in use, approximately one-sixth of the possible output voltage of the cathode follower is applied to the amplifier grid. By this means, we have arranged that there is a negligible change in volume when the filter is cut in and out of circuit.

The remainder of the circuit consists of a B.F.O., employing a Colpitts oscillator circuit. It uses the spare winding that was removed from the transformer that was modified for use in the grid circuit of the EF42. Since a tuning capacity of 100 $\mu\mu$fd. is needed with this coil, the tuning capacity is made up of two 200 $\mu\mu$fd. condensers in series, with the junction earthed, to provide the feedback connection for the Colpitts circuit. A 20 $\mu\mu$fd. trfimming condenser is connected across the lower of the two 200 $\mu\mu$fd. condensers and is brought out to the front panel for use as a fine frequency control. The degree of control exercised by this condenser is just great enough to match the tuned frequency of the audio filter, which is 1,000 c/sec. That is to say, a variation of about plus and minus 1,000 cycles is achieved by this means, so that, wherever the condenser is set, it can never be far from the required setting if the frequency has initially been set to the exact I.F. centre by means of the tuning slug of the B.F.O. coil. The output of the B.F.O. is attached to the "cold" end of the secondary of the last I.F. transformer, in the drawing of the I.F. amplifier. Please note that the amplitude of oscillation is quite low, owing to the 250k. plate resistor, so that should more B.F.O. voltage be needed, it can easily be provided by lowering the value of this resistor. The on/off switch for the B.F.O. has been ganged with another switch which connects a 0.5 μfd. condenser across the A.V.C. line, in order to give a very long time-constant, and prevent the sensitivity of the receiver from coming up between characters and even between words and sentences. This allows the A.V.C. to be kept on during C.W. reception; this, in turn, makes it possible to find an optimum

(Continued on Page 33.)

The "RADIO and ELECTRONICS" Abstract Service

AERIALS AND TRANSMISSION LINES

The utility of the vertical antenna for the lower amateur frequencies remains a subject for argument. The antenna described is vertical and made of 4 in. galvanized iron downpiping, guyed, and insulated at earth. A comparison is made with the horizontal aerials, and notes are given for erection and tuning.

—QST (U.S.A.), May, 1952, p. 11.

AUDIO EQUIPMENT AND DESIGN

Some problems in audio frequency analysis are discussed. Many of these become increasingly difficult at low frequencies where the time of one cycle becomes comparable with the total time available for the analysis. The article deals with the response of a tuned circuit to a signal of varying frequency.

—Electronic Engineer (Eng.), July, 1952, p. 268.

An investigation into the mechanism of magnetic recording wherein the practice has for some time been in advance of theory. The effect of asymetry is investigated and shown to give distinctive properties to the recording and distortion characteristics. The use of A.C. bias is discussed and also the effect of the gap in the recording head.

—Proceedings of the I.E.E. (Eng.), Part III, No. 59, Vol. 99, p. 109.

With increased popularity of tape-recorders, more users are beginning to do their own tape editing. The "tricks of the trade" are described by a professional tape editor, and will aid the results. —Audio Engineering (U.S.A.), May, 1952, p. 15.

The use of positive feedback will nullify the effect of voice coil impedance. The use of positive feedback is discussed, with illustrations of convenient means of applying the feedback and some argument as to its uses. —Ibid., p. 20 and also p. 21.

Voltage divider action of a typical amplifier coupling circuit often produces a hum voltage across the succeeding tube. A unique method is described for employing the noises and hum arising from a power supply to cancel themselves out, and by applying them to a following stage in the correct phase and amplitude. —Ibid., p. 22.

CIRCUITS AND CIRCUIT ELEMENTS

Some new multivibrators; details of new free-running multivibrators are introduced which are interesting due to the peculiar arrangement of their circuit elements.

—Electronic Engineering (Eng.), July, 1952, p. 270.

ELECTRONIC DEVICES

Slope control for resistance welding. Primarily, where the initial resistance of the weld is high or inconsistent, the gradual increase of welding current improves the work. Back-to-back thyratrons serve as automatically varying resistances across the heat control to make the A.C. current increase gradually from initial to final value. —Electronics (U.S.A.), May, 1952, p. 124.

The dynamic hysteresis loop of a magnetic material is important for designing magnetic amplifiers. The apparatus shows flux density versus magnetizing flux characteristics in very clear detail.

—Electrical Engineering (U.S.A.), July, 1952, p. 518.

INSTRUMENTS AND TEST GEAR

A crystal oscilloscope capacitance meter consists of a valve with a quartz crystal between grid and cathode and a tuned circuit in the anode. The latter is so adjusted that at resonance of the crystal the anode impedance is slightly inductive, and a small change in capacitance causes a large change in anode current, which is the basis of the meter's working.

—Electronic Engineering (Eng.), July, 1952, p. 284.

Millimicrosecond pulse techniques; this is part of an article which deals with oscillograph equipment to view very fast waveforms; also a description of apparatus for expanding milimicrosecond pulse intervals on an analogue principle, and examples of application to laboratory measurements are suggested in the conclusion.

The oscilloscope is a very useful instrument for the designer, but from the angle of the serviceman it is very much over-rated. Beginners are inclined to believe that it should take a place with the multimeter and the oscillator, but this is not the case. The use and abuse of the instrument are discussed.

—Radio and Hobbies (Aust.), May, 1952, p. 81.

Magic-eye tuning indicators described. The modus operandi given with a few typical circuits in common use.

—Ibid., p. 75.

The design and equipment of an instrument for the continuous recording of very small R.F. noise powers received from the sun and galaxy. The practical difficulties inherent in the measurement have been overcome by self-balancing equipment where a locally-produced noise is balanced against receiver power.

—Proceedings of the I.E.E. (Eng.), Vol. 99, No. 59, p. 127.

MATERIALS, VALVES, AND SUBSIDIARY TECHNIQUES

The increasing development effort devoted to high-power klystrons has brought about rapid improvements in the characteristics of transmitter types. There has been an increase in power, efficiency, tuning, and temperature compensation.

—Proceedings of the I.R.E. (U.S.A.), April, 1952, p. 465.

It is indeed interesting to see a comprehensive circuit with transistor symbols in place of the valves which have been for so long regarded as indispensable. The circuit is a frequency-shift teletype converter, which comprises an R.F. amplifier, mixer-limiter amplifier, and discriminator. The power drawn is 1.5 watts and the weight six pounds. The main disadvantage is the effect of ambient temperature variations.

—Electronics (U.S.A.), May, 1952, p. 98.

Glow discharge tubes. In the tube described there are 10 main cathodes arranged in a circle which fire in a certain order. The tube has a number of applications as a counting device with very high speed operation.

—Electronic Engineering (Eng.), June, 1952, p. 272.

A small ring-shaped ferromagnetic core with rectangular BH characteristics may be operated with various windings so that its flux polarity reverses by special excitation. Such cores may then be used as memory devices and assembled into a two or three-dimensional system.

—Proceedings of the I.R.E. (U.S.A.), April, 1952, p. 475.

There are now many articles appearing on transistors and transistor techniques. The fons et origo of the transistor, the Bell Laboratories, now publish a statement on present developments. With respect to reproducibility and interchangeability, transistors appear equal to commercial vacuum tubes. For temperature effects they are inferior to valves, and this is one of the main disadvantages which is yet to be overcome.

—Bell System Technical Journal, May, 1952, p. 411.

A magnetic recording material composed of rubber impregnated with magnetic oxide and lubricant is particularly suited for certain applications such as the continuous repetition of short messages. Simple and economical records have been produced in this way. —Ibid., p. 530.

Mica in the form of a continuous thin coherent sheet will soon make its appearance in electrical insulation. The credit goes to a Frenchman, J. Bardet. The raw material is muscovite mica in waste or scrap form; it is heated to produce partial dehydration and immersed in a solution of sodium carbonate. From this stage, continuous sheets are produced, and the advent of the process may bring a new era to certain types of electrical insulation.

—Electrical Engineering (U.S.A.), May, 1952, p. 463.

PROPAGATION

It is shown that there is an optimum ground station antenna height for air-to-ground communications; below this, the range is reduced; above, there is interference between direct and reflected waves. This is of importance to air navigation where the frequencies used are above 50 mc.

—Proceedings of the I.R.E. (U.S.A.), April, 1952, p. 470.

A continuation of an earlier article on the factors which influence the change of wavelength. Mention is made of "duct formation," where the waves are trapped in gradients of water vapour; the scatter by opaque objects is also mentioned, and the uses of frequency and pulse modulation and receiver techniques.

—QST (U.S.A.), May, 1952, p. 32.

TELEVISION

Phase linearity, phase shift proportional to frequency produces a TV picture most faithfully. Production receivers can be designed with narrow bandwidth and linear phase shift for sharpening pictures without smear. Practical circuits given showing the best set-up and amplifier design.

—Electronics (U.S.A.), May, 1952, p. 103.

TRANSMITTERS AND TRANSMITTING

A midget 50-watter is described; packaged in a 4 in. x 5 in. x 6 in. cabinet, the transmitter has a crystal oscillator working to a 6AG7 and 6BQ6-GT as the amplifier. The usual construction details are given for this handy rig.

—QST (U.S.A.), May, 1952, p. 27.

It can be said that a transmitter is not better than its final amplifier, and this applies especially to single-sideband transmission. The article deals with the testing and alignment of such an amplifier with oscilloscope patterns as the guide.

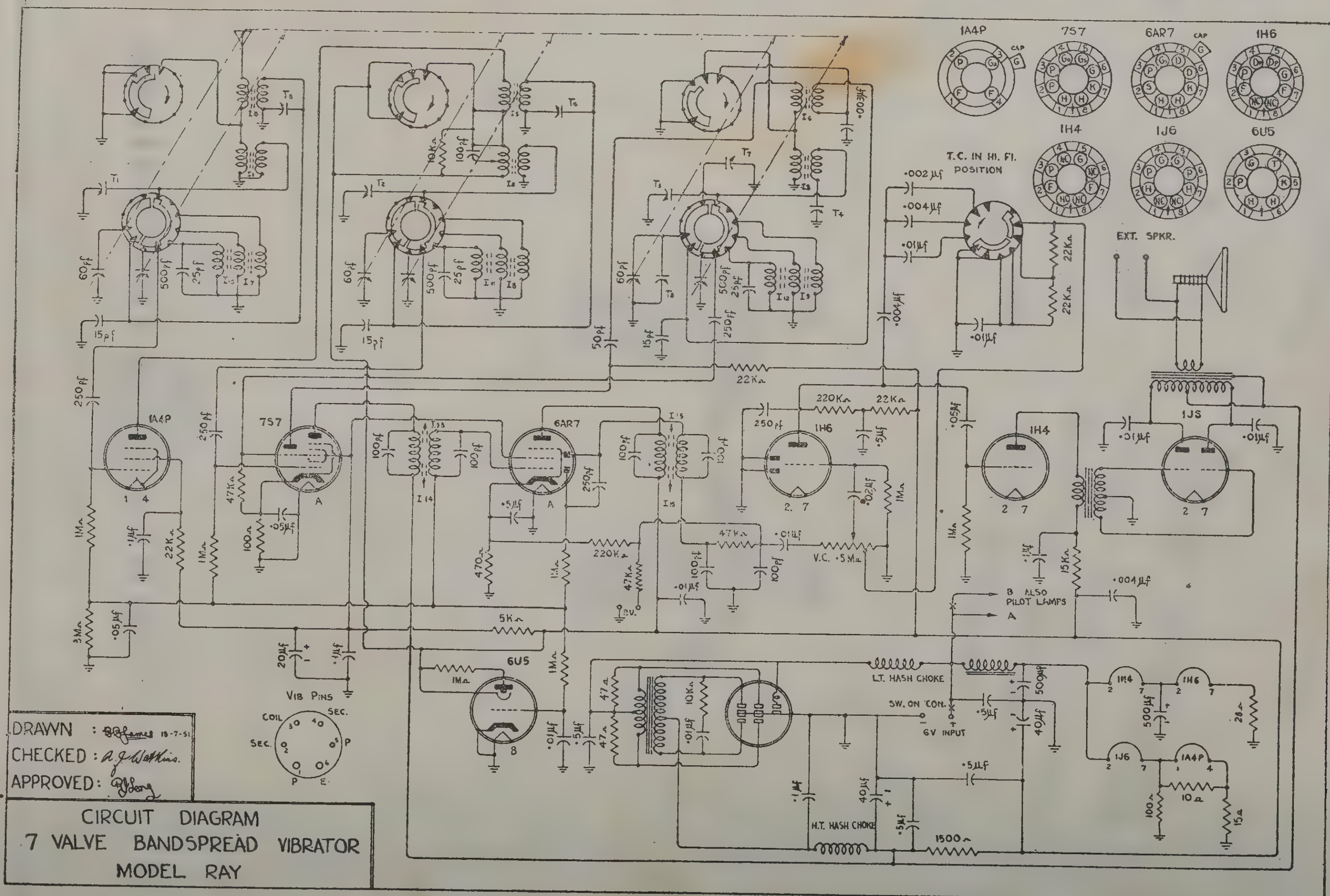
—Ibid., p. 39.

A modulation indicator which should be very handy for the amateur. The circuit given makes use of the fact that when a signal is modulated 100 per cent. or more in a negative direction periods of no-signal result, and a magic eye is adapted to indicate

(Continued on Page 48.)

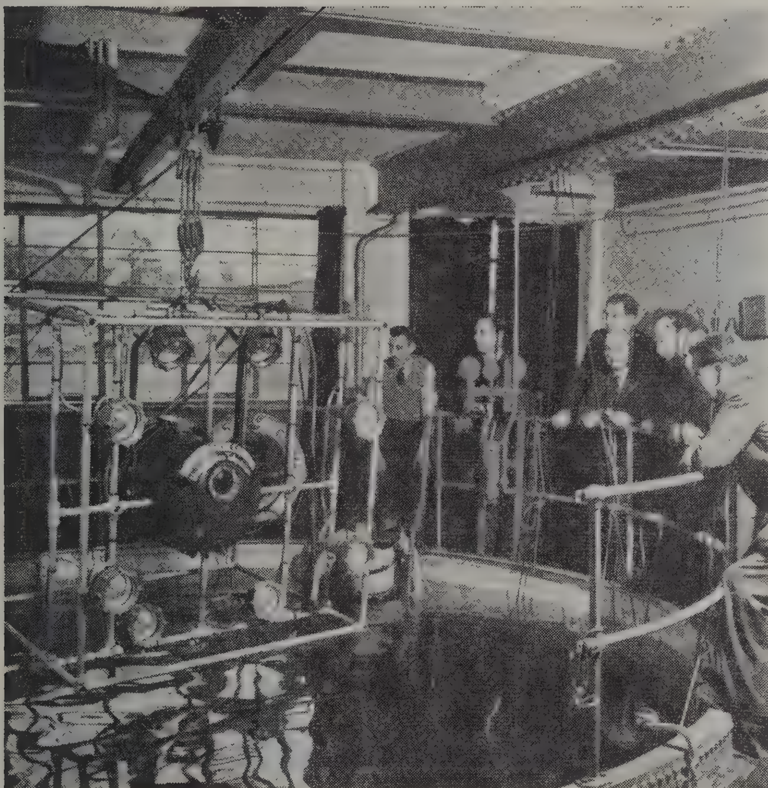
FOR THE SERVICEMAN:

The "Ultimate" 7-Valve Bandspread Vibrator Receiver Model RAY



Television Covers the Sea Bed

By Donald MacRow



Lowering a Marconi-Siebe-Gorman camera into a tank for demonstration. The only lights needed to operate the camera are shown ringed on a "free-flow" framework around it.

Underwater television equipment is being produced by several British firms for use by the Royal Navy and by salvage and dockyard interests.

The positive identification of the hulk of *H.M.S. Affray*, submarine lost in the English Channel in the spring of 1951, was the first time that underwater TV was put to practical use. The basic idea was as old as television in any form and most of the optical and mechanical problems associated with underwater equipment were overcome in the study of under-water photography by the Admiralty Research Laboratory and the Group Recherchez Sousmarines of the French Admiralty.

In May, 1951, it became apparent that the search for the *Affray* had resolved itself into the identification of many unknown wrecks located in the search area by acoustic means. Television gave the positive information as to which wreck was *Affray* herself. A normal broadcast television camera built by Marconi's Wireless Telegraph Company was given a waterproof container by the Royal Navy Scientific Service and operated for more than 300 hours underwater during the search and subsequent survey of the lost submarine.

Investigations have continued. Visibility under water varies considerably, from the thick, muddy water of an estuary to 80-90 feet visibility found in some parts of the Mediterranean. Where *Affray* was lost, about 10 miles north-west of the Casquets, the water was comparatively clear, and conditions of 40 feet of visibility were sometimes found.

In British coastal waters, artificial lighting is usually necessary at reasonable depths. Ordinary electric lamps were generally found to give the best overall effect, though in specific conditions it is thought possible that sodium discharge lighting might help. In the *Affray* search, a normal diver's lamp was used. It has been found possible to achieve a field of 70 degrees behind a plain window, and spherical windows have been found to have little advantage. Picture definition with the broadcast type of equipment, when used over a closed circuit which does not include radio transmission, is of far better quality than is necessary for normal work.

Below: Swedish naval officers (left) watch the demonstration of the under-water TV camera on a monitoring screen. The engineer at the control panel can change lenses, adjust focus and aperture, from his desk while the camera is on the sea-bed.

Messrs. Pye Radio Ltd., of Cambridge, England, have produced further cameras for the Royal Navy, and Messrs. Electric and Musical Industries, Ltd., of Hayes, England, are developing a machine for the Scottish Marine Biological Association. The problem of the complex, multi-core underwater cable to link the camera with the surface has been overcome by British Insulated Callendars Cable Co., Ltd.

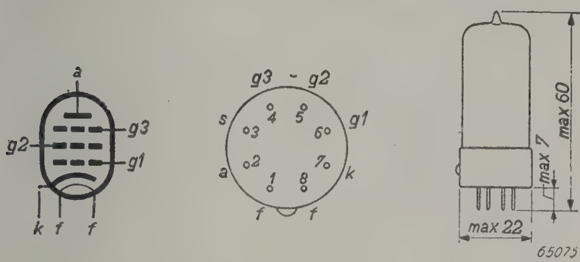
The end of a long search. The experimental TV camera picks up the name plate on the side of the lost submarine "Affray," one of the 300-odd wrecks located by acoustic means in the area of the search. Only this visual evidence could prove that the lost ship had, in fact, been found.

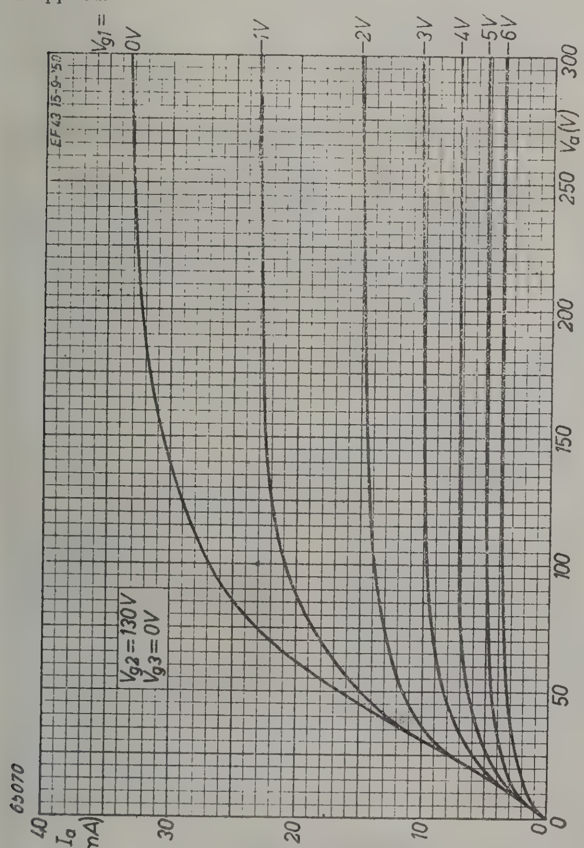
Given suitable conditions, use of the equipment is foreseen to include seabed survey, salvage, hull-inspection, dock and harbour survey, marine biological research. For instance, a smooth hillock of sand at 200 ft. depth was seen by the *Affray* search equipment to be occupied by a solitary crab. The cameras are capable of working deeper than any diver, and for longer periods than a diving bell. There is no risk to life and the picture is presented directly to experts on the surface instead of being relayed through a verbal description. The use of salvage grabs and similar gear in conjunction with the TV equipment should make normal salvage work very much more satisfactory. The new cameras built by Pye Radio Ltd., have an operational depth of 1,000 ft. and have built-in facilities for changing lens focus and aperture whilst under water. With such equipment, the development of remotely-operated tools for salvage should produce few difficulties.

TUBE DATA: The EF43 R.F. Variable-Mu Pentode

In the design of a combined receiver for A.M. and F.M. the aim will be, purely for reasons of economy, to reduce the number of tubes required to the minimum. Tubes that are used in the F.M. channel should therefore, also be applied, as far as possible, for A.M. reception. In the A.F. section of the receiver this does not entail any difficulties, but in the I.F. or H.F. parts with A.M. a tube with remote cut-off is required, to prevent the occurrence of heavy cross modulation when A.G.C. is applied.

***BASE CONNECTIONS AND DIMENSIONS IN* mm**





Anode current of the EF43 as a function of the anode voltage with the grid bias as a parameter.

The EF43 has been specially designed to satisfy the need for a pentode that can be used for wide-band amplification as well as for H.F. or I.F. amplification in the normal broadcast band.

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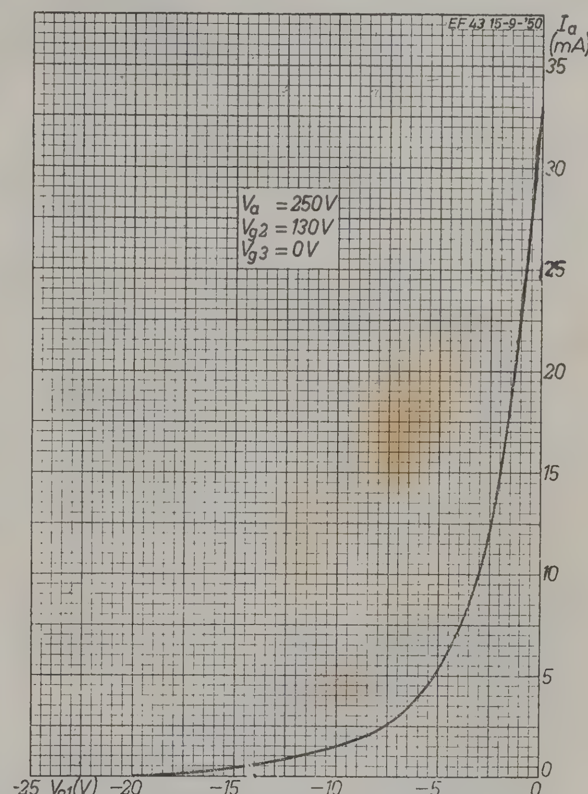


Anode current of the EF43 as a function of the negative grid bias.

A mutual conductance of 6.3 mA/V may be considered sufficient for normal wide-band applications, whilst the cross modulation curve is such that it is comparable with normal broadcast types. Owing to the high slope and the high circuit impedances involved, when the EF43 is used as I.F. amplifier with A.M., it will be necessary to take special measures to ensure stability. These measures may consist of suitable taps on the I.F. transformers.

TECHNICAL DATA

The technical data of the EF43 given here are of a provisional nature and may be subject to small alterations.

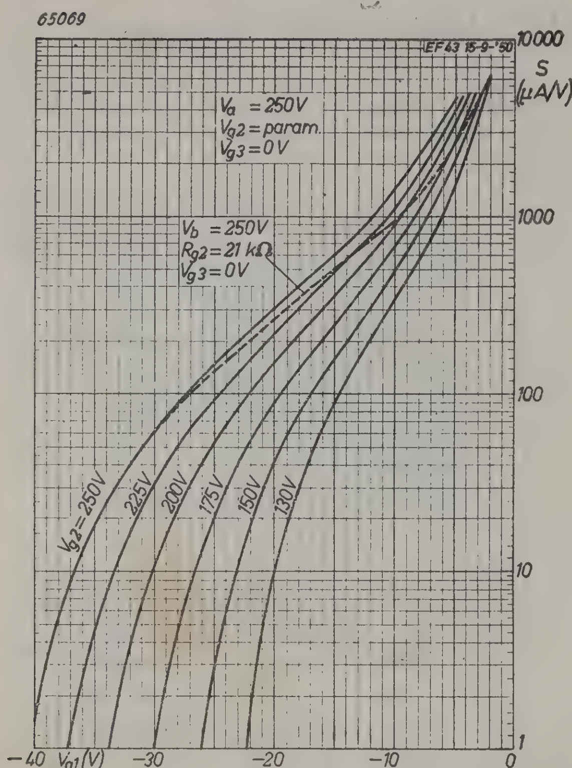
Heater Data

Heating: Indirect by A.C. or D.C.; parallel supply.

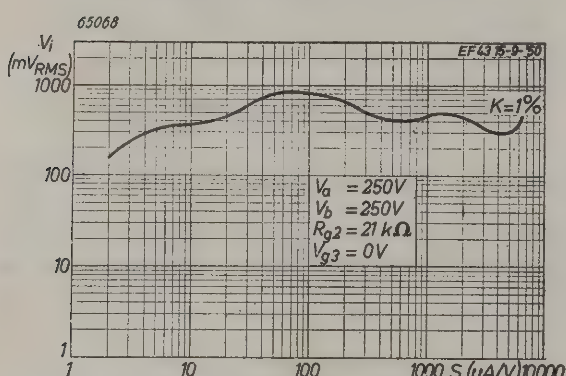
Heater voltage	V_f	6.3 V
Heater current	I_f	0.33 A

Capacitances

Input	C_{g1}	8.5 pF
Output	C_a	4.3 pF
Control-grid to anode	C_{ag1}	<0.006 pF
Control-grid to heater	C_{g1f}	<0.2 pF



Mutual conductance of the EF43 as a function of of the grid bias with the screen-grid voltage as parameter. The dotted curve applies for varying screen grid voltage, $R_{g2} = 33k\Omega$.



Input signal in mVrms for a cross modulation of 1 per cent. as a function of the mutual conductance.

Typical Characteristics

Anode voltage and supply voltage	$V_a=V_b$		250		V
Suppressor grid voltage	V_{g3}		0		V
Screen grid resistor	R_{g2}		21		kΩ
Control grid voltage	V_{g1}	—2	—13	—30	V
Anode current	I_a	15			mA
Screen grid current	I_{g2}	5.7			mA
Mutual conductance	S	6300	630	63	μA/V
Internal resistance	R_i	0.6			MΩ
Amplification factor between screen grid and control grid	μ_{g2g1}	30			
Equivalent noise resistance	R_{eq}	2.5			kΩ

Mounting Position: Any

Limiting Values

Anode voltage at zero anode current	V_{ao}	max.	550	V
Anode voltage	V_a	max.	300	V
Screen grid voltage at zero screen grid current	V_{g2o}	max.	550	V
Screen grid voltage	V_{g2}	max.	250	V
Grid bias	V_{g1}	max.	—100	V
Grid current starting point (grid current + 0.3 μA)	V_{g1}	max.	—1.3	V
Voltage between heater and cathode	V_{kf}	max.	100	V
Average cathode current	I_k	max.	25	mA
Anode dissipation	W_a	max.	3.75	W
Screen grid dissipation	W_{g2}	max.	0.8	W
External resistance between control grid and cathode; with automatic bias	R_{g1}	max.	1	MΩ
External resistance between heater and cathode	R_{kf}	max.	20	MΩ

Philips Experimenter

(Continued from Page 25.)

setting for the B.F.O. output voltage that will give the same output volume, regardless of the signal strength at the input of the receiver.

CONSTRUCTION OF THE FILTER

Fortunately, the use of Philips Ferroxcube cores enables anyone to build the chokes without recourse to gear that will measure inductance. If the bobbins are wound according to instructions, given earlier in this article, the inductances will turn out to be so nearly correct as to make no practical difference. The most important thing is to have the two tuned circuits of the filter resonating at the same frequency, namely, 1,000 c/sec., or quite close to it. If this is done, the characteristic of the filter will have a flat portion only about 50 cycles wide, falling off very sharply on either side. There is no need to draw a response curve to make sure that the filter is working properly. The fact can be very easily heard simply by listening to the output while the beat not is changed. Except for the narrow band passed by the filter, the note is almost inaudible, so that interfering heterodynes very close to the desired signal have very little chance at all of being a nuisance. When the chokes have been wound, a stock 0.002 μfd. condenser can be connected across the 13.9H. choke, and an audio oscillator set to the resonant frequency of the combination by connecting both the oscillator and a pair of phones, or a V.T.V.M. across it. This frequency is noted. Then the same thing is done for the small choke and the 1.46 μfd. condenser. A 1μfd. and a 0.5 μfd. are connected in parallel, and the resonant frequency found as before. If it is the same as that obtained for the other components, then it will do, and the filter can be wired up. If it is considerably different, the value of the condensers can be juggled with until it comes to the correct figure.

CONSTRUCTION

Comparison of the photograph reproduced here with the one in Experimenter No. 58 will show which are the added components corresponding to this month's circuit. If the page is turned in a clockwise direction so that the row of controls is uppermost, the Ferroxcube pot cores can be seen in the right-hand lower corner, with the large paper tuning condenser near at hand. This was a nominal 2 μfd. that turned out to have exactly the right value of 1.46 μfd., and so was used. The valve on the extreme right is the Philips ECC40, while the first one to its left is the Philips EF41 B.F.O. valve. The controls, right to left, are: Filter on/off switch, B.F.O. pitch condenser, and B.F.O. on/off switch, with the other three controls as detailed earlier in this series. On the back of the chassis is the phone jack, and next to it is the 0.25 μfd. output coupling condenser. The condenser at the left is the 0.5 μfd. A.V.C. time-

(Continued on Page 48.)

Trade Winds

WELLINGTON RADIO TRADERS' ASSOCIATION

At the last meeting of this association, held on 21st July, 1952, the chairman, Mr. W. Young, gave a resume of the various matters discussed at the recent federation annual conference and the subsequent executive meeting.

Members approved the federation's decision to publish the police lists of "stolen radios" only in "Radio and Electronics," and to discontinue the internal distribution of these lists.

The new transfer badge has been ordered and is expected to be available shortly. Each member will be supplied with two badges at a cost of 2s. 6d. each.

The extension of the federation activities to embrace various household electrical appliances—a matter which had been considered at the annual conference and the subsequent executive meeting—was again discussed, this time from the angle of the problems involved rather than on broad principles. Though the proposal met with general favour, it was felt that more detailed examination was required, particularly with regard to the amount of work involved and the extent of the coverage. Accordingly, a subcommittee consisting of Messrs. W. Young, W. Bradbury, K. Elliott, and Kerr was appointed to examine the question and report to the association's annual meeting.

The improvements required in the proposed second edition of the Trade-in Handbook were fully discussed, members considering it essential that this booklet should be in a form easily read and understood by the customer. After considering the method by which the trade-in values should be calculated, the meeting finally resolved, with Mr. Billing dissenting, that, subject to the two following provisos, the former scale be adopted. The provisos are:

(a) No trade-in value would be assessed at less than £1. If the percentage calculation should show a figure of less than £1, it should be increased to that amount.

(b) All trade-in values to be recorded in multiples of 5s.

Members were advised that the first issue of the Bulletin would be issued within the next fortnight.

The date of the annual meeting of the association was set for 18th August, 1952, at 7.30 p.m.

* * *

NEW ZEALAND RADIO-TELEVISION AND ELECTRICAL TRADERS' ASSOCIATION AUCKLAND

Reviewing activities during his term of office, the president, Mr. S. Christie, in presenting his annual report, thanked the Executive for their assistance and co-operation during the past year. He mentioned that total membership of the association stood at 131, and drew the attention of all dealers in the province to the necessity of supporting the association, not only with subscriptions, but also with presence, suggestions, and advice at meetings, thus assisting a better understanding of difficulties and a solution of problems. The credit balance of £86 16s. 9d. he considered most heartening, especially as it succeeds last year's heavy deficit. He reported on discussions with the Employers' Association concerning the present conciliation proceedings in the proposed new award covering servicemen. Though several clauses had been suggested by the executive, it was felt that a more opportune time to press these matters would occur in the coming year. The outgoing executive had kept up to date the lists of bona fide dealers, but the decision regarding the continuation of these will rest with the new executive. At the request of members, two separate meetings of the wholesale section of the association had been held under the chairmanship of Mr. H. J. Barr. Since separation from the federation, members have received advice from the condenser manufacturers of the inclusion of their names on the latter's lists. As his pièce de résistance, Mr. Christie informed members that the activities of the executive in recognizing the necessity for an early approach to the Government with regard to television had resulted in a grant of approximately £2,600 for the equipping and formation of advanced classes at the Seddon Memorial Technical College for the training of servicemen. These classes are well attended and are now approaching their first term examinations.

At the annual general meeting of the above association, held on 22nd July, the election of officers resulted as follows:—

President: Mr. C. R. Peoples.
Vice-President: Mr. M. C. L. Rhodes.
Immediate Past President: Mr. S. Christie.
Secretary: Mr. J. E. Beachen.
Executive: Messrs. H. J. Barr, W. J. Murphy, D. Green, Waldo Hunter, J. Waller, T. S.

Kirkpatrick, J. K. Brackenridge, J. Walch, and R. R. Stephen.

It was resolved that the executive be authorized to proceed with the incorporation of the association under the Incorporated Societies Act.

With regard to the Local Apprenticeship Committee, members were informed that, in view of the setting up of a separate apprenticeship order for the radio industry, it was likely that the present local committee would be dissolved and a new committee formed. However, the district commissioner will advise the association of any pending change.

Greetings were read from Mr. Fairclough, past-president of the New Zealand Radio and Television Radio Traders' Federation, and a letter was received from Mr. S. Souper, president of the federation, asking that the Auckland association give consideration to rejoining the federation. After much discussion, however, it was finally resolved that in the meantime no action should be taken.

With regard to dry batteries, it was recommended that the executive should first approach the Board of Trade for the granting of a limited licence for the importation of all types of batteries on the grounds that the imported article would relieve the present stock position.

The present arrangements made with Ducon (N.Z.) Ltd. for supplies of condensers through local wholesalers were considered satisfactory. It was left to the wholesale section to make a recommendation concerning import licences.

On the question of car radios, however, it was resolved that the executive be directed to look further into the matter of import and of the retailing angle of motor dealers and their method of servicing car radios.

Further business was postponed until the next general meeting, but the annual meeting concluded with a unanimous vote of thanks to the immediate past president, M. S. Christie, and his executive for their services during the past twelve months.

* * *

RECORD DOLLAR ORDER FOR SABRE JET SIMULATORS

As part of the defence programme of the Western Powers, the Canadian Government (Department of Defence Production) has placed an order with a British firm for nearly 3,000,000 dollars for flight simulators for Sabre jet fighter aircraft. This order—the largest dollar order for electronic equipment of this type ever placed in the United Kingdom—was received by Redifon Limited, the manufacturing company of the broadcast relay service group in the face of strong competition from the United States.

The flight simulator, which will be used by the Royal Canadian Air Force, produces on the ground by electronic means the various conditions experienced by air crews in actual flight. The flight deck is exactly reproduced complete with every instrument which is normally in the aircraft. The instruments continuously and cumulatively register in the same way as the corresponding instruments in actual flight. The simulator enables aircrews to undergo periodic training checks or conversion courses and to familiarize themselves with the procedures and emergency drills necessary for the satisfactory operation of the aircraft under both normal and abnormal conditions. The instructor is able to introduce emergency or adverse conditions calling for corrective action on the part of the pilot.

Earlier types of Redifon electronic training devices saved valuable lives, scarce fuel, aircraft hours, and many thousands of pounds during the last war, and since that time considerable technical advances have been made in the field of electronics from which have evolved the modern flight simulator. The use of flight simulators results in a great economy of flying time and a more thorough training, as with this equipment crews can be made to undertake much more hazardous training operations.

Redifon have previously provided a flight simulator to train crews of the B.O.A.C. stratocruisers, and are now delivering one for the new Comet jet airliner. Simulators for other types of aircraft are now in the design or production stage.

Back at work after a bout of mumps, Ken Stephen is breathing fire and vengeance on this malady. His good looks, alas, were not improved by the framing of red flannel, and the groans and mumbles issuing forth from the wrappings needed no amplifier. "Why pick on me?" has been his sad refrain!

* * *

Green & Cooper, Ltd., have secured an order from the Ashburton Electric Power Board for the supply and installation of Pye tele-communication equipment comprising one 15-watt base station and nine mobile units. Located at the top of a 96 ft. mast situated at the power board's premises, the aerial for this equipment will provide complete coverage for the board's district and enable rapid contact to be made with its breakdown gangs.

* * *

ARE WE BEING LEFT BEHIND IN THE TV RACE?

We have received recently so many reports of television developments in other parts of the world that it would appear that New Zealand and Australia are being left well behind in the TV field. Just to show that this is no idle statement, here are a few reports of the kind mentioned.

"The Bayerischer Rundfunk (Bavarian Broadcast Corporation) is making plans for television broadcast-

Proceedings of the New Zealand Electronics Institute Incorporated.

ANNUAL GENERAL MEETING OF THE INSTITUTE

This meeting was held in the Air Department Building, Wellington, on Wednesday, 30th July, at 5.30 p.m. Mr. W. D. Foster took the chair in the absence of the President, Mr. W. L. Harrison, who was overseas.

Apologies for absence were sustained from Messrs. Collier, Slade, Harrison, and Askey.

After approval of the minutes of the third annual general meeting, matters arising were discussed and explanations given by the chairman concerning the implementation of the recommendations made in the minutes.

The annual report and statement of accounts were read and adopted, subject to audit, and the auditor, Mr. F. E. Feist, of Pattrick, Feist, Jack & Middlebrook, was reappoited auditor for the year ending 31st May, 1953.

No business was brought forward under the agenda heading of "general," and the chairman declared the meeting closed.

WELLINGTON BRANCH

Following the annual general meeting of the institute, the Wellington branch held its July general meeting, at which equipment demonstrations were given by Messrs. F. W. Cropley and W. D. Foster.

Demonstration of "Fonadek," by Mr. F. W. Cropley

The Fonadek is fitted with a three-stage resist-abling a telephone conversation to be carried out without the need for holding the handset, the latter being held by the Fonadek, which, by means of a suitable shaped horn, concentrates sound pick-up into

the microphone. The earpiece lies against the Fonadek pick-up inductance, which relies on the stray magnetic field from the earpiece for its pick-up.

The "Fonadek" is fitted with a three-stage resistance coupled amplifier with 1.5v. tubes operated from a combination of 69v./1.5v. battery and feeding a small loudspeaker fitted into the case. An additional loudspeaker may be used as an accessory for conference work, and under these conditions the unit is quite satisfactory for operation up to a range of 10 feet.

Mr. Dippy assisted with the demonstration by conversing with the meeting from another room.

Demonstration of Radio-Controlled Positioning Device by Mr. W. D. Foster, B.Sc.

The radio-controlled positioning device demonstrated by Mr. Foster was constructed in strictly portable fashion and adequately demonstrated its application to model control.

The transmitter is square-wave gated and produces continuous wave trains of constant amplitude during the "on" period of each square wave. The position-setting control operates on the "mark/space" principle, the mark/space, or ratio of power on to power off during each cycle, being varied by this control.

The receiver uses a super-regenerative detector giving a constant pulse amplitude output of 4v. peak to peak. This is rectified by independent positive and negative rectifiers, the resultant D.C. voltage being mixed and applied to the grid of the relay tube. The voltage applied to the grid of this tube becomes of varying magnitude of positive or negative voltage according to the mark/space ratio.

The relay is a miniature double-wound polarized type which is in the "off" position with zero or balanced currents. A reference current is applied to one coil during operative conditions. The contacts operate the control motor, which, in addition to performing the required function, drive a potentiometer which feeds positive or negative voltage into the grid circuit of the relay tube, the motor continuing to drive until the current in the tube is made to balance the reference relay current.

Although it takes a definite "off balance" voltage to cause the relay to come in again, the small amount of freedom is of little account in the application for which it is intended.

Drawing Curves on the Oscilloscope

(Continued from Page 15.)

vice versa, have been drawn much more lightly than the rest of the pattern. This is because these portions do not appear on the screen, being too fast to be seen. It might be wondered how a continuous picture is built up in this manner. The action illustrated in Fig. 3 does not appear as a stationary pattern on the screen unless

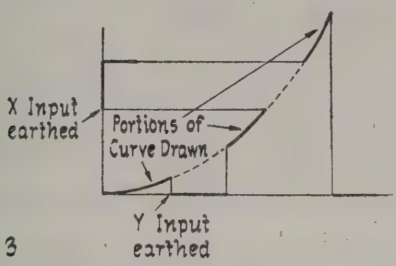


Fig. 3

the switching frequency is an exact multiple of the signal frequency. That being the case, a different portion of the curve and of each axis is drawn during each cycle of the signal, so that the visible pattern is actually built up during several cycles of the signal.

If the signal frequency is much higher than the vibrator frequency, the action is a little easier to visualize. Indeed, no diagram is needed. All that happens under these circumstances is that while the vibrator reed is in each of its three conditions, several cycles of the signal occur. (To be Continued.)

NEW PRODUCTS: LATEST RELEASES IN ELECTRICAL AND ELECTRONIC EQUIPMENT

This section of our paper is reserved for the introduction of new products and space preference is given to our regular advertisers. Advertising rates are charged according to space occupied. For further particulars contact Advertising Manager, R. and E., Box 8022, Wellington.

A.W.A. VOLTOHMYST

Newly on the market in New Zealand is the A.W.A. Voltohmyst—an exceedingly comprehensive electronic test meter covering a wide range of A.C. and D.C. measurements. Technical specifications are as follows:—

CHARACTERISTICS

D.C. Voltmeter and D.C. Milliammeter

Seven continuous ranges: 0 to 1.5, 5, 15, 50, 150, 500, 1500 volts and mA.

Input resistance (including 1 megohm in D.C. probe): All ranges, 11 megohms.

Sensitivity for the 1.5-volt range: 7.3 megohms per volt.

Overall accuracy: ± 3 per cent. of full scale.

A.C. Voltmeter—Fourteen continuous ranges:

Peak-to-peak ranges: 0 to 4, 14, 42, 140, 420, 1400, 4200 volts.

R.M.S. ranges (for sine waves): 0 to 1.5, 5, 15, 50, 150 500, 1500 volts.

Input resistance and capacitance with Direct Probe and Cable:

1.5, 5, 15, 50, 150-volt ranges: 0.83 megohm shunted by 90 $\mu\mu$f.

500-volt range: 1.3 megohms shunted by 90 $\mu\mu$f.

1500-volt range: 1.5 megohms shunted by 90 $\mu\mu$f.

Frequency response with Direct Probe and Cable:

1.5, 5, 15, 150, 500-volt ranges flat from 30 cps to 2.5 mc/sec. for voltage source.

Response with Xtal probe 50 kc/sec. to 250 mc/sec. having 100-ohm impedance, or lower.

Overall accuracy:
All ranges: ± 5 per cent. of full scale.

Maximum Input Voltages:

D.C. voltage (with no A.C. voltage present): 1500 volts.

A.C. voltage (with no D.C. voltage present):
R.M.S. for sine waves: 1200 volts.
Peak-to-peak for sine waves: 3400 volts.
Peak-to-peak for complex waves: 1400 volts.

Combined A.C. and D.C. voltages:
Sum of D.C. and peak A.C. voltages: 1400 volts.

Ohmmeter:
Seven continuous ranges: 0 to 1000 megohms.
Centre scale values: 10, 100, 1000, 10,000 ohms; 0.1, 1, 10 megohms.

Meter Movement:
D.C. current for full-scale deflection: 200 μA.
Valve Complement: 1–12AU7—2–6AL5.

Power Supply:
Voltage rating: 220-260 volts.
Frequency rating: 50/60 cps.
Power consumption (approx.): 9 watts.
Battery (1.5-volt cell).

Overall dimensions: 10 in. high, 6¼ in. wide, 5 in. deep.

Weight: 8½ lb.
Finish: twilight blue dimenso case—maroon panel.
Available from Amalgamated Wireless (Australasia) Limited.

Distinguished Visitor Lectures In Wellington

In last month's issue of *Radio and Electronics,* a short account was given of the research activities of Mr. J. A. Ratcliffe, the present radio research chief at the Cavendish laboratories, Cambridge, who visited New Zealand for a short time last month.

While in Wellington, Mr. Ratcliffe lectured to the physics section of the Wellington Branch of the New Zealand Royal Society, on "Movement and Irregularities in the Ionosphere," a subject upon which he and his team of workers have been engaged for a considerable time. The topic was a most interesting one, and the lecturer's happy facility for stripping what is necessarily a rather abstruse subject down to its bare essentials, made an interesting evening, even for those among the audience who had had little or no prior knowledge of ionospheric reesarch.

Mr. Ratcliffe traced the discovery of the so-called ionospheric winds back to the early days of propagation research, when Appleton and Barnett were first engaged in investigations of the ionosphere by pulse methods. It had been observed that the echoes from an ionized layer were not constant in amplitude, but were subject to rapid variations. It was proved that these variations

were due to the beating together at the receiver of numerous signals scattered from widely separated parts of the reflecting layer. However, by application to the problem of the Fresnel diffraction theory (which, though first developed with relation to light waves, is applicable to all electromagnetic radiations) the extent of the portion of ionosphere that it concerned in a single reflection was calculated, and likewise the distance apart of the receiver and transmitter at which vertical-incidence observations should be free from multi-path interference effects. When a receiver and transmitter were then set up under the conditions suggested by the theory, it was found that fluctuations in receiver signal strength were still observed. It was the systematic investigation of these residual fluctuations which showed that the cause must be variations in absorption (and therefore in reflection) due to a steady drift of a non-homogeneous ionosphere. The practical investigations were again based on the Fresnel diffraction theory, by means of which it is possible to calculate the fine structure of a diffracting surface by observing the diffraction pattern produced.

At the present time, very litttle is known about the ionospheric winds, except that they exist and can be measured, by a simple technique developed by Ratcliffe and his co-workers, involving the use of two continuously recording receivers, spaced a suitable distance apart. The lecturer showed numerous slides illustrating the results that have been obtained at Cambridge, some of them bearing dates as recent as the previous month!

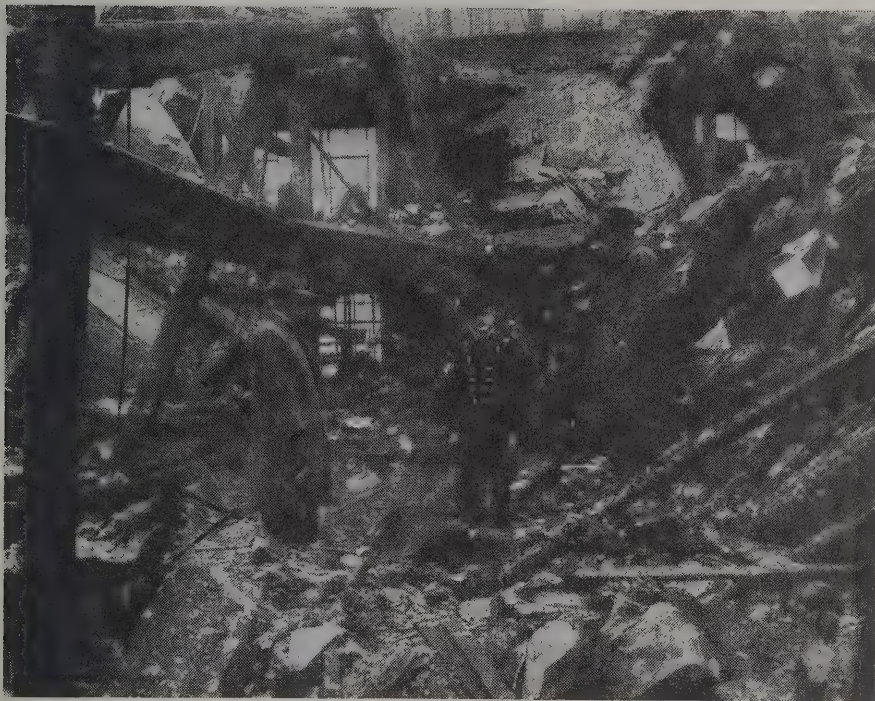
In thanking Mr. Ratcliffe for his address, Dr. A. G. Bogle emphasized the value to us, in our remoteness from the centres of most of the world's scientific research, of receiving visits from leaders in the various fields in which we ourselves were playing some part, and remarked that the present instance, the recency of some of the results discussed by the lecturer showed that it would hardly be possible to obtain scientific information more "straight from the horse's mouth."

Judging by the number of questions the lecturer was called upon to ansyer at the conclusion of his address, the large audience was extremely interested—as it could hardly fail to be in view of Mr. Ratcliffe's subject, and the extreme clarity of his exposition.

"RADIO-GEN"

Is now on sale, price 9d. a copy, or subscription 10s. per annum posted. Obtain your copy from Radio Dealers, or write to "Radio and Electronics," P.O. Box 8022, Wellington.

DISASTER IN THE INDUSTRY



Portion of the raw material store into which fell the fourth and fifth floors, their contents, and the roof. The floor is covered with wreckage to an average depth of eight feet and when this photo was taken, five days after the fire, smoke was still rising and the brigade were still using their hoses. In the picture Mr. J. S. Oxley, Manager of Swan's factory, with Mr. Chas. Roser of "Radio and Electronics," are being guided by a watchman of the fire brigade.

At 3 p.m. on Wednesday, 30th July, the factory staff of the Swan Electric Company in Wellington left their work benches for the afternoon tea break. Fifteen minutes later they left their work benches again, as a precautionary measure, due to the outbreak of a small blaze in the exhaust flue of the factory spray booth. No one supposed the evacuation would be of any great duration, but with frightening speed, the hungry flames resisted the company's extinguishers and the hoses of the brigadesmen, until, eventually, the whole of the five storey portion of Hope Gibbons Building belched forth smoke and flame.

When finally the fire was brought under control, the fifth and fourth floors were destroyed and the third floor —occupied by Swan Electric Company—was a gutted ruin open to the skies and piled high with smoking debris.

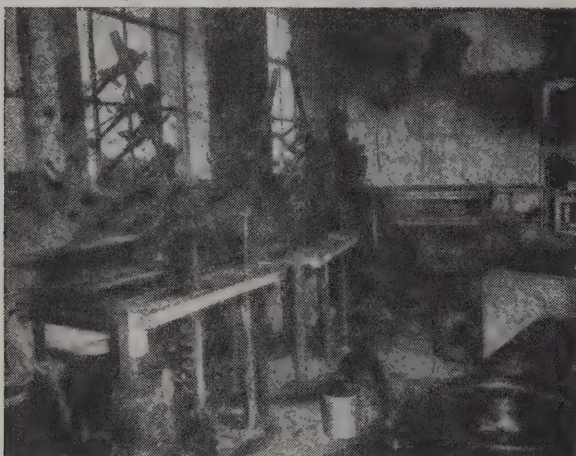
In the factory, Swan Electric produced the Rola loudspeakers, transformers, fluorescent lighting components, etc., and this terrible disaster is a great blow to the company.

Fortunately, the fire caused no loss of life. In an interview with *Radio and Electronics,* the Factory Manager, Mr. Staff Oxley, stated that the entire staff of 50 have been kept on the company's pay-roll and already many have been employed on salvage of the plant and assembly jigs not completely destroyed during the fire. His first concern is to obtain new premises so that the company can recommence speaker production. Meanwhile, temporary arrangements have been made with other Wellington manufacturers for a limited output of speakers and transformers in the latter's premises. Escorting Mr. Chas. Roser of *Radio and Electronics* over the burned-out ruins, Mr. Oxley expressed great appreciation of the numerous offers of sympathy and help he had received from all sections of the trade.

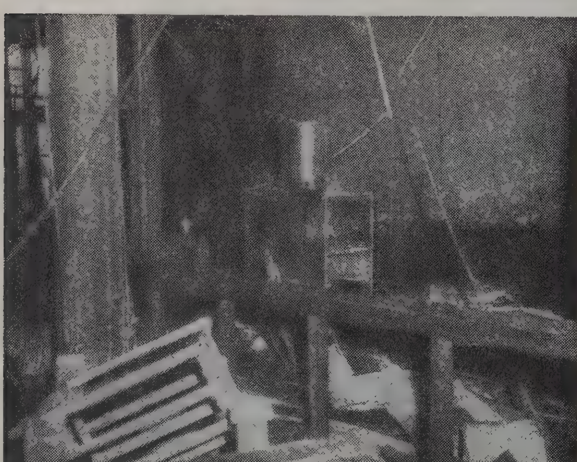
A batch of completed 10 in. Rola speakers awaiting final testing at the time of the fire. Beyond the trays of speakers stood the test booth, of which nothing remains.

THERE WILL BE CONTINUITY OF SPEAKERS

In the factory at the time of the outbreak was the Managing Director of the Company, Mr. Wm. J. Blackwell, who quickly organized emergency measures to cope with the serious situation facing his company and the radio trade of New Zealand. A few days after the fire,



Salvaged primary winders, pressers, and other plant stacked in a corner of the building ready for dispatch for overhaul.



The burned-out spray booth in which the fire started.

Radio and Electronics interviewed Mr. Blackwell, who stated that measures taken within several hours of the outbreak of the fire would ensure but little break in continuity of loudspeaker supplies to the radio manufacturers and retail and servicing trade. Several types of Rola loudspeakers were already in plentiful supply and this condition would rapidly apply to all current models. He was determined that none of the company's employees would suffer as a result of the fire.

The loss of the factory's raw materials was a serious blow, due to the current shortage of overseas exchange, but at the time of making the statement, replacement

A view from the fifth floor level looking down through the fourth floor to the raw material store of Swan Electric, piled eight feet high with smouldering rubble. Note the twisted and broken 12 in. steel girders.

parts were on their way from Australia by air freight and other express means.

Mr. Blackwell paid tribute to the trade in general, for quick and generous offers of assistance with plant, materials, and space; so much so, in fact, that already Swan Electric Co. factory employees were producing loudspeakers from the factory of Radio Corporation of New Zealand, Limited, and transformers in the factory of Collier and Beale, Limited. Naturally this production is limited in types and quantity, but to safeguard the overall supply of speakers, arrangements have been made with the Government to permit some quantities of Rola speakers to be imported from Swan's associate company, the Rola Company of Australia. Mr. Blackwell also paid a tribute to the various Government Departments who so readily sanctioned this emergency action and also to the Reserve Bank of New Zealand for making available emergency foreign exchange.

In conclusion, Mr. Blackwell stated that no efforts would be spared to locate suitable premises and recommence normal production of all of those items being produced by the Wellington factory before the fire.

We are sure that the radio trade of New Zealand joins with us in extending our deepest sympathy to the Swan Electric Company in their dreadful calamity, and our appreciation of the company's astonishingly quick and forthright handling of the situation in the interests of the trade.

TWO MODELS to choose FROM

TECNICO — the first electric lawnmower made specially to suit the domestic lawn. It mows and trims in one operation . . . is light, sturdy, and easily handled. With its unique scything action (blade performing up to 10,000 cutting actions a minute. The Tecnico Electric Lawn Mower will cut the most stubborn grass.

Easy adjustment lever gives you choice of three cutting heights! Almost without vibration—wear cut to minimum—due to dynamically balanced armature! No interference in your radio — or neighbours' — thanks to suppressor in *all* Tecnico appliances! No lubrication needed for years—bearings are grease-packed and then sealed!

tecnico

ELECTRIC LAWNMOWERS

Sole New Zealand Distributors:

H. W. CLARKE (N.Z.) LTD.

AUCKLAND — WELLINGTON — CHRISTCHURCH — DUNEDIN

Poor Man's Signal Generator

(Continued from Page 13.)

the built-in 455 kc/sec. signal generator. The next thing is to set the dial pointer according to the instructions given by the maker of the coil kit. Next, the set is turned on, and, with the main dial set somewhere near the 1400 kc/sec. mark, the oscillator trimmer is adjusted until a signal is heard. The signal is identified, so that its frequency can be known, whereupon the dial reading will tell whether or not the oscillator trimmer is too far in or too far out. This should normally be set at about two-thirds the way in, and if no signal can be picked up round about 1400, it can be set in this position. The multivibrator is then turned on, and the aerial and R.F. trimmers are adjusted for loudest output. Next, the dial is set at 600 kc/sec., and the padder is adjusted for loudest output. In this condition, the set may not be properly aligned with the dial, but it should be well enough aligned for stations to be heard at most parts of it at night. A check can now be made to see where on the dial the main broadcast stations come in. Pick one as close to the high-frequency end of the dial as possible, and check its frequency against the dial reading. If this is too high or too low, set the dial at the correct spot, and then re-tune the station, using the oscillator trimmer condenser. The multivibrator is then brought into action again, and the aerial and R.F. trimmers re-peaked. The padder is then adjusted in the same way as before, and a further check will now show that the stations come in more nearly on their correct dial markings than they did at the first attempt. By repeating the process once or twice more, the alignment can be completed, with the knowledge that it will have been as well done as is possible with the best signal generator and output meter.

Philips Experimenter

(Continued from Page 33.)

constant lengthener. Incidentally, only one of the Ferroxcube cores can be seen, since the two of them are mounted one above the other.

In conclusion, we would like to express the opinion that for serious communication work under exacting conditions, the "back end" formed by these two circuits should out-perform any commercial receivers, and will be a joy to those harassed by today's all too prevalent Q.R.M.

"R. and E." Abstract Service

(Continued from Page 26.)

lapses. The higher the percentage of modulation, the more the closure of the eye. —Ibid., p. 69.

MISCELLANEOUS

Radio progress during 1951. This is a very interesting summary and gives the development and the important bibliography for the year. Reports on electron tubes, audio techniques, various theories, television, and all matters of importance in the U.S.A.

—Proceedings of the I.R.E., April, 1952, p. 382.

The anodizing of aluminium is often of use for radio apparatus; the article deals with the theory and methods, referring to the chromic acid process and dyeing or multichrome dyeing.

—Electronic Engineering (Eng.), June, 1952, p. 281.